REPORT OF SURVEY CONDUCTED AT

LOCKHEED MARTIN
NAVAL ELECTRONICS & SURVEILLANCE
SYSTEMS-SURFACE SYSTEMS
MOORESTOWN, NJ

AUGUST 2001

Best Manufacturing Practices

1998 Award Winner

INNOVATIONS IN AMERICAN GOVERNMENT

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Foreword

This report was produced by the Office of Naval Research's Best Manufacturing Practices (BMP) Program, a unique industry and government cooperative technology transfer effort that improves the competitiveness of America's industrial base both here and abroad. Our main goal at BMP is to increase the quality, reliability, and maintainability of goods produced by American firms. The primary objective toward this goal is simple: to identify best practices, document them, and then encourage industry and government to share information about them.

The BMP Program set out in 1985 to help businesses by identifying, researching, and promoting exceptional manufacturing practices, methods, and procedures in design, test, production, facilities, logistics, and management – all areas which are highlighted in the Department of Defense's 4245.7-M, *Transition from Development to Production* manual. By fostering the sharing of information across industry lines, BMP has become a resource in helping companies identify their weak areas and examine how other companies have improved similar situations. This sharing of ideas allows companies to learn from others' attempts and to avoid costly and time-consuming duplication.

BMP identifies and documents best practices by conducting in-depth, voluntary surveys such as this one at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, Moorestown, New Jersey conducted during the week of August 20, 2001. Teams of BMP experts work hand-in-hand on-site with the company to examine existing practices, uncover best practices, and identify areas for even better practices.

The final survey report, which details the findings, is distributed electronically and in hard copy to thousands of representatives from industry, government, and academia throughout the U.S. and Canada – *so the knowledge can be shared*. BMP also distributes this information through several interactive services which include CD-ROMs and a World Wide Web Home Page located on the Internet at http://www.bmpcoe.org. The actual exchange of detailed data is between companies at their discretion.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is the prime contractor for manufacturing and integration of the Aegis Weapons System and Aegis Depot Operations for the Navy. Its successful history in large-scale systems integration, radar technology, software development, microelectronics, lifetime support, vertical launching systems, and fire control systems enabled the company to establish a solid foundation for creating future innovative solutions. Among the best examples were Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' accomplishments in Signal Integrity; Shared Vision: Research and Development Funding; Emergency Response Team; Transmit/Receive Module Assembly; Lean and Six Sigma; Proposal Database; Manpower Analysis Process; and Backfit Programs Test Facility.

The BMP Program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems expand BMP's contribution toward its goal of a stronger, more competitive, globally-minded, and environmentally-conscious American industrial program.

I encourage your participation and use of this unique resource.

Anne Marie T. SuPrise, Ph.D.
Director, Best Manufacturing Practices

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Section 1

Report Summary

Background

The Lockheed Martin Corporation comprises all or portions of 17 heritage companies, including those of aviation pioneers Glenn L. Martin and the Loughead [*sic*] brothers. Although its founders were dreamers, they could never have imagined the extent to which their company would actually contribute to shaping the future. Lockheed Martin's pioneering efforts created a legacy of excellence and innovation. Continuing in this tradition, the corporation is striving to strengthen its competitiveness and advance its high standard of performance and dependability. Today, Lockheed Martin is engaged in the conception, research, design, development, manufacture, integration, and operation of advanced technology systems, products, and services. The corporation serves customers in both domestic and international defense and commercial markets, with its principal customers being agencies of the U.S. Government. With its corporate headquarters in Bethesda, Maryland, Lockheed Martin is organized into five business segments, employs 130,000 personnel in the United States and overseas, and achieved $25.3 billion in sales for 2000.

The BMP survey focused on the Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems in Moorestown, New Jersey which employs 4,350 personnel and achieved $25.3 billion in sales for 2000. This facility was established in 1953 as part of the RCA Corporation and later merged with General Electric-Aerospace Group; sold to Martin Marietta in 1992; and merged with Lockheed in 1995. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is part of the Systems Integration segment ($9.6 million in sales in 2000) which engages in the design, development, integration, and production of high performance electronic systems for undersea, shipboard, land, and airborne applications. Among the best practices documented were Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' Signal Integrity; Shared Vision: Research and Development Funding; Emergency Response Team; Transmit/Receive Module Assembly; Lean and Six Sigma; Proposal Database; Manpower Analysis Process; and Backfit Programs Test Facility.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is the prime contractor for manufacturing and integration of the Aegis Weapons System and Aegis Depot Operations for the Navy. Its successful history in large-scale systems integration, radar technology, software development, microelectronics, lifetime support, vertical launching systems, and fire control systems enabled the company to establish a solid foundation for creating future innovative solutions. Noteworthy achievements include: first ballistic missile early warning system; active solid-state phased array radar systems; lunar space rendezvous radar; automated intercontinental ballistic missile launch control system; range instrumentation radar; and first multi-warfare combat system. Moorestown operates as the main facility of the Naval Electronics & Surveillance Systems-Surface Systems. Additional operations are located in Baltimore, Maryland and Mount Laurel and Camden, New Jersey.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems continues to build on decades of experience in developing advanced next-generation systems to meet future needs. In addition to supporting this mission, the company provides outstanding community outreach programs; partners with local businesses and academia; and pioneers environmental efforts. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has received numerous awards including the New Jersey Quality Award (1994), the Commissioner's Recycling Award (2000), and the prestigious James S. Cogwell Outstanding Industrial Security Achievement Award (2000). The BMP survey team considers the practices in this report to be among the best in industry and government.

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Section 2

Best Practices

Design

Automated Data Storage and Retrieval System

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has realized significant savings by implementing an Automated Data Storage and Retrieval System. As a result, configuration management cost and engineering data needs have been streamlined and brought to the next generation of highly efficient data management.

In the past, every engineering drawing released under configuration control had five sets of aperture card films created for each sheet of every drawing. These aperture card films were maintained in the print room and delivered to the customer, suppliers, and drawing archive facility. Print requests were handled through the Engineering Document Control Organization. This approach required multiple personnel to perform these duties, and created massive amounts of paper, aperture card films, and facility requirements. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems soon recognized a need for rapid access by any team member to engineering drawings, Engineering Change Notices (ECNs), parts lists, and problem sheets which are recognized/approved by all involved. The result was an Automated Data Storage and Retrieval System that operates as a document and data delivery system, and provides on-line rapid access to engineering drawings, ECNs, parts lists, and problem sheets via a web browser.

The Automated Data Storage and Retrieval System affords a powerful company-wide document distribution capability across local and wide area Intranet networks. The system operates as a complete Intranet server solution that provides integrated document service capabilities (e.g., document capture and import; automated document indexing; revision control; on-line viewing with standard web browser; complete drawing packages; print services for printing anywhere on the network; e-mail interface for workgroup collaboration). Figure 2-1 shows an outline of the overall process.

In creating this process, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems learned many lessons in achieving a smooth transition. Among these were to initially establish clearly defined roles and responsibilities of the team composition, and to set up the integrated test environment midway through transition to validate proper operation. The company now makes support documentation mandatory prior to the process tran-

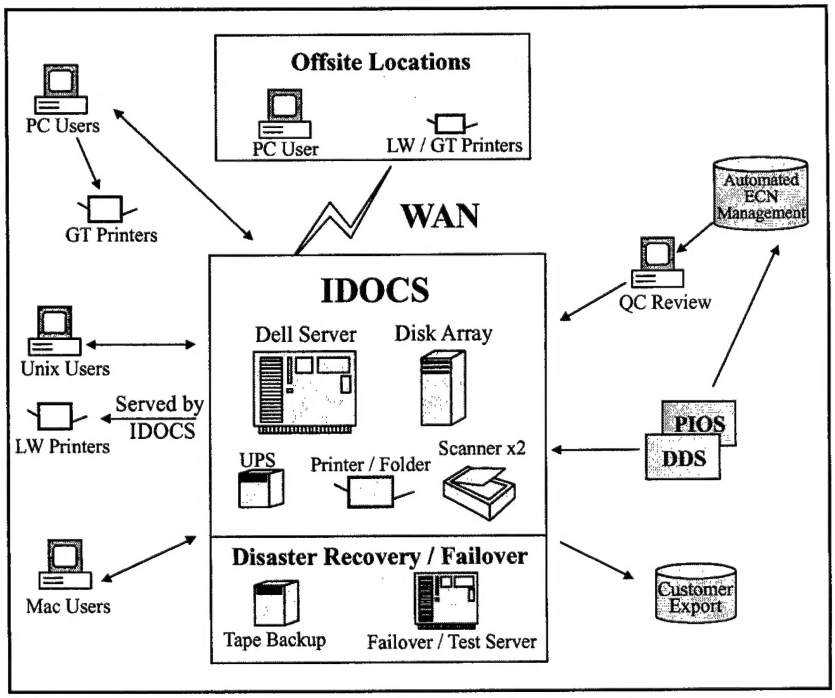


Figure 2-1. Data Storage and Retrieval System

sition for such documents as Project Specification; Concept of Operations; System Requirements; System Design; Functional Specification; and System Administration Requirements.

Since implementing the Automated Data Storage and Retrieval System, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems realized many benefits. The company improved Product Data Management effectiveness through real-time access to engineering documents; and increased engineering process efficiencies through the use of an electronic document generation, rework, and delivery process. Global accessibility to engineering documentation information now allows access to all involved parties; and easy access to data maximizes engineering productivity. The company also reduced its configuration management costs by 40%, just in the areas of record retention, printing, and delivery.

Collaborative Engineering Environment

The Naval Systems Computing Center at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has developed, implemented, and manages a sophisticated computing and networking environment to meet Navy Combat System Engineering requirements across many programs. This Collaborative Engineering Environment technologically co-locates teams through load sharing, and uses a unique set of processes and procedures to maximize performance and operating efficiencies.

Previously at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, many obstacles hindered the use of a collaborative engineering environment including classified stand-alone networks; limited facilities for on-site teams; limited telecommunication technologies; and poor avenues for sharing data. However, the nature of Navy programs requires networking across multiple projects and domains. In response, the Naval Systems Computing Center (NSCC) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed a sophisticated computing and networking environment to meet Navy Combat System Engineering requirements.

The Collaborative Engineering Environment (CEE) enables geographically-dispersed teams, consisting of hundreds of members, to interact. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems can now support classified and unclassified information across its network through load sharing of teams, rather than spending huge amounts on housing costs to physically co-locate teams. NSCC also implemented a unique set of processes and procedures to maximize performance and operating efficiencies. These consist of Network Management and Security; Engineering Tool Management; Software License Management; and Software Integration and Test Equipment Management.

Since being implemented, CEE has provided Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with numerous benefits. Among these include: eliminating redundant equipment procedures; sharing network infrastructures for both voice and data; reducing engineering development costs through automation; maximizing investments in software tool training; increasing test efficiencies through collaborative development/tactical tests; and providing real-time training and mentoring processes. Standardized software and commercial-off-the-shelf (COTS) products allow integrated software license tools to be used by the engineering population. All of these elements save time, manpower, and drive down costs. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems was also recognized by the Defense Security Services for "Excellence in Network Security."

Cost Estimate Process

The Cost Estimate Process provides guidance to the Technical Operations staff for preparing Technical Operations cost estimates. The process addresses cost estimate types, documentation, reviews, approvals, and is intended to complement the Cost Estimate Manual.

Previously at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, cost estimating involved three engineering organizations. The overall process of each organization lacked standardization, ranging from ad hoc to fully documented processes. When the company reorganized these groups into one Technical Operations Division under a single vice president, the organization identified the opportunity to standardize the Cost Estimate Process. As such, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed a standard process that is fully cognizant of the company's cost estimates, comple-

tion status, resource commitments, and level of confidence in each estimate.

Based on standard input and requirements from customers, a cost estimate is categorized as one of four types: Budgetary, Rough Order of Magnitude, Not to Exceed, or Proposal. Each type has its own significant risks, strategic importance, or unique requirements. The Cost Estimate Process involves three phases. The phase, Planning, involves establishing a technical baseline; preparing an internal estimate request; identifying the Technical and Financial Operations Leads; gaining agreement on the estimate type; and holding a kick-off meeting with the cost estimate team to review all pertinent data. Afterwards, the Technical Operations Lead logs in the cost estimate. The next phase, Functional Estimating, involves development of the cost estimate by the Technical Operations Lead and the Responsible Individuals. The First Level Manager and the initial Center Director then review basis of the estimate, and the data is entered into the Proposal Support System to obtain cost accumulation and verification. The final phase, Management Review, involves the Responsible Individuals reviewing the cost estimate with their Center Directors and obtaining a sign-off. The Technical Operations Lead then prepares a cost estimate review package for review by the Staff Directors. If required, the Technical Operations Vice President may also review the estimate. Once the estimate is approved, the Technical Operations Lead submits the documentation to the Technical Operations Cost Estimate Administrator for entry into the Proposal Database. The estimate is also archived for future reference and use on similar products, thereby providing the company with more consistent estimates.

Since implementing the Cost Estimate Process, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced its cost estimate generation and review effort while delivering a more robust cost estimate. The entire company has buy-in of the cost estimate and is cognizant of the cost estimates that are in-process or pending acceptance by customers. Management can also predict staffing requirements based on all the estimates. The Cost Estimate Process provides the company with a better understanding of the cost estimate, hence a higher probability of mission success.

Embedded, Commercial-off-the-Shelf, Digital Signal Processor Benchmarking, Sizing, and Simulation

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems facilitated a move from proprietary hardware to commercial-off-the-shelf hardware for complex radar systems by introducing an iterative design, test, and simulation process. This process provides benefits in scalability, platform independence, program schedules, and costs.

In the past for very technically complex radar systems, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems designed and built proprietary hardware components in-house, which were combined to construct digital signal processors (DSPs). While the proprietary hardware scheme fulfilled the stringent performance requirements, the cost was higher than tolerable in a commercial-off-the-shelf (COTS) era. Because many proprietary hardware elements were unique, these elements often required dedicated customized software. This very rigid hardware/software architecture led to a rigidly sequential design-and-test process. Many hardware elements and their supporting software had to be built, tested, and fully analyzed before another hardware/software set could be designed and/or tested. As a result, the design cycle was stretched out; no software performance measurements were possible early-on; and all meaningful system testing occurred late in the program schedule where changes are costly. In response, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed an iterative design and test regime for embedded COTS DSPs that identifies risk early and saves time and money.

In the Embedded COTS DSP Benchmarking, Sizing, and Simulation regime, the design test and simulation process is iterative. The process employs COTS hardware, and the software design uses standard C-Language Application Program Interfaces (APIs). Embedded refers to accessing COTS hardware at the API level. Since the hardware has uniform COTS elements, its behavior is well known and predictable. Similarly, the interface of the software with the hardware through standard APIs is uniform and predictable. Therefore, design engineers take advantage of these traits to 'build a little, test a little' and focus on the overall system performance, rather than the details of unique hardware/

software pairings. Numerous other benefits arise from this process. Designs are easily scalable since the crucial computational software algorithms can be written to take advantage of standard APIs and uniform hardware.

A C-Language simulator can examine the impact of input/output operations on a full-scale DSP fairly early-on. The design is platform independent, as different vendors' COTS hardware elements are typically interchangeable to adhere to performance and interface requirements. The iterations of the process are:

- Iteration 0 - Benchmarks established by vendor at vendor site.
- Iteration 1 - Initial simplified software algorithms designed and tested on scaled-down DSP.
- Iteration 2 - Full software algorithms designed and tested on scaled-down DSP.
- Iteration 3 - Optimization for initial release on full DSP.
- Iteration 4 through N - Incremental functionality designed and tested.

Since the Embedded COTS DSP Benchmarking, Sizing, and Simulation regime was implemented, the primary savings to Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is time. Because productive design starts immediately, the design cycle is now shortened. By catching software errors early-on, the high costs of correcting software later in coding are minimized. Another benefit is early identification of problems in the design and test stages, which leads to a higher confidence in risk estimations. Because the hardware and software elements are fairly uniform and scalable, the company can be more confident that the risks identified early will be representative of risks identified later.

Integrated Data Environment

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has developed a web-based collaborative environment for on-line, real-time exchange of program, project, product, and production data. The Integrated Data Environment is an award-winning system which contains large cost and schedule benefits.

In the past, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems utilized traditional paper-generated documentation. Facsimiles and e-mails were the means for transferring information to team members for reviews, approvals, and obtaining program documentation. This time-consuming approach lacked structure and created inefficiencies and long review cycles. Realizing that collaboration alone increases speed and communications, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems focused on key areas to improve its process: access to information; external access by subcontractors and customers; iterative approach and release of capability; user acceptance; and "build a little, test a little, deploy a little." The result was a web-based collaborative environment for on-line, real-time exchange of program, project, product, and production data.

The Integrated Data Environment includes information management, program management, contract management, collaborative contracts, and pricing web sites to encompass all possible areas for increased efficiencies. The system operates a secure environment for both internal and external users, and is a multiple program solution which makes documents simultaneously available to all team members. A virtual work environment, involving the complete supply chain from customer through subcontractor, was also created.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has realized many quantifiable and qualitative benefits from the Integrated Data Environment. During proposal generation and review, the company along with all external parties were able to work in the virtual environment thereby eliminating travel and hotel expenses. Other quantifiable savings included: cycle time reduction of key activities; re-deployment of staffing through workflow; enhanced configuration management; and reduced and earlier rework. Qualitative advantages included: initial foundations of knowledge management; enhanced external focus and attentiveness; improved cooperation with partners and subcontractors; and facilitation in going global.

Since 1995, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced the cost-per-page of its paper-based Technical Manuals by 16% by transitioning to Interactive Electronic Technical Manuals (IETMs). The Integrated Data Environment also reduces the delivery time of IETMs from 14 days to one hour. In 1999, the company's technical manual deficiency/evaluation reports rate was 50% less than the previous year, and this trend is continuing to improve. A Process Oriented Contract Administrative Service (PROCAS) agreement among the Defense Contract Management Com-

mand; the Naval Surface Warfare Center, Port Hueneme Division; and Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced the delivery process from 33 days to less than three. The cycle time for source data replication, distribution, and tracking was also decreased from 80 hours per Technical Manual to zero hours by using a common database. The Integrated Data Environment has won numerous awards including Lockheed Martin EPI Center's Booz-Allen & Hamilton Best Practices (1997); Lockheed Martin GES Evening of Excellence's Team of the Year Award (1998); and the Association for Enterprise Integration's CALS Implementor Honor Roll Award (1998).

Mechanical, Commercial-off-the-Shelf Design Practices

When using commercial-off-the-shelf equipment, the utilization of vendor data without verification may result in qualification testing failures. By verifying these design parameters via its Mechanical, Commercial-off-the-Shelf Design Practices, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has realized critical design requirements for commercial-off-the-shelf enclosures and avoided costly redesign in dealing with commercial-off-the-shelf, non-conformance issues.

The validation of commercial-off-the-shelf (COTS) items for military operability has always been an issue of deep concern. In the past, designs at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems relied almost completely on analysis with minimal testing performed prior to environmental qualification. Since analysis assumptions and results could not be fully verified until qualification testing, this approach led to two issues: (1) Problems found in qualification are more expensive to fix than those found earlier in the design process, and (2) Testing late can lead to high costs, particularly in COTS parts where design margins are less than those of MIL-SPEC parts. Additionally when outside testing was employed, the test house collected, organized, and presented the test data back to the company. By relying on vendor presentations, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems often encountered a productivity issue since the data would not be organized as preferred. The solution was the development of the Mechanical COTS Design Practices.

The Mechanical COTS Design Practices enabled Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to move its design process toward risk reduction testing when designing packaging for COTS equipment. This approach includes the design, analysis, and testing of hardware prior to environmental qualification. These Design Practices also enabled the company to use its own data collection methods and equipment at test houses. This way, the company no longer needs to rely on the vendor's data collection, analysis, and presentation techniques/practices.

Since being implemented, the Mechanical COTS Design Practices enable Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to reduce program costs and develop more robust designs. The combined benefits of analysis and risk reduction testing saved a recent program approximately $120,000 in enclosure material costs alone. By validating its COTS designs early in the process, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has been able to design enclosures to deal with compliance issues early in the design process, and has not been required to change enclosure designs which has and could result in unusable enclosure material purchases.

Mechanical Computer Aided Design/ Computer Aided Manufacturing

Faced with increasing competition, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems set out to improve its engineering design and manufacturing reliability through the use of concentric modeling and a common hardware / software suite. This philosophy has reduced costs and increased the company's competitive posture in the marketplace.

In the past at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, designs were passed to subcontractors via 2-D drawings. Minimal high-end design data was also shared between internal sites. Errors were typically introduced into the process because of incomplete translation techniques and multiple computer aided design (CAD)/computer aided manufacturing (CAM) systems. Many parameters often had to be re-created for engineering analysis and manufacturing use. To resolve these issues, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Mechanical CAD/CAM process.

The process came about through the efforts of an Engineering Process Improvement Subcouncil. The Subcouncil, composed of site experts from various Lockheed Martin plants, provided direction, standardized engineering processes within the company, and established a path for keeping the company's engineering department at the forefront of technology. As a result, the Mechanical CAD/CAM process uses a seamless method to effectively transfer 3-D parametric models to other corporate sites, subcontractors, and suppliers. Only one part or assembly model is used throughout the entire design and manufacturing process, thereby eliminating the chance of errors being introduced by data translation/re-creation from another system. Everyone works with the same concentric model. This approach greatly improves the reliability associated with product design, interoperability, and manufacturing when using multiple locations. All components can be designed and manufactured from the same models using intelligent data parameters.

The Mechanical CAD/CAM process enables Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to improve communications among users as well as increase productivity and design reliability. The process also employs model-centric data transfer, common software tools, and a preferred hardware platform to facilitate transfer of non-CAD data. During the process' test period, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems saved $28,000 on two separate projects. The company plans to implement this process on all of its programs.

Mechanical Computer Aided Design/ Computer Aided Manufacturing Analysis

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is moving its design engineers into the analysis business to increase product performance. Engineers are performing finite element analysis to optimize their designs earlier in the design process. Simpler analysis tools that seamlessly pass model geometry between the design and analysis are playing a key part in improving engineering processes.

In the past, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems performed Finite Element Analysis (FEA) by utilizing high-end tools. To effectively use these tools, analysts had to be highly skilled and needed to re-create the designer's model before performing the analysis. The model was then modified and the analysis repeated to find the optimal performance. Once completed, the design model would be updated with the model changes. Often, many chip geometries were repeatedly created and analyzed before the optimum geometry was ascertained. This approach can introduce errors into the model and minimize productivity due to data re-creation. The high-end tools also limited the design engineer's ability to develop complex models; therefore, experts were often required on every job. To resolve these issues, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Mechanical Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) Analysis process.

The process came about through the efforts of an Engineering Process Improvement Subcouncil. The Subcouncil, composed of site experts from various Lockheed Martin plants, standardized the engineering processes within the company. The Subcouncil also reviewed the situation of design engineers on the ease of performing FEA on parametric models. The result was the Mechanical CAD/CAM Analysis process, which employs a simple FEA tool that uses the same model geometry as the design package of the design engineers.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' philosophy is to optimize performance and cost parameters, quickly and efficiently, early in the design cycle. The Mechanical CAD/CAM Analysis process enables design engineers to perform analyses on-the-fly and rapidly test iterative design alternatives. Simpler codes, like MacroFlow, are used to supplement the analysis and, in some cases, replace high-end tools. The design engineer is also encouraged to build parametric analysis models that can be readily updated. Parametric modeling reduces errors introduced during re-creation of the model geometries, as well as increases the productivity of engineers and throughput of the engineering department. On one particular program, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems estimated its savings in process labor at $13,000.

Shared Vision: Research and Development Funding

Lockheed Martin and General Electric's Corporate Research and Development Center have developed a shared-vision research and development funding program. This co-investment allows both companies to obtain more research for less investment dollars, and creates many opportunities for bringing new technologies to market.

The heritage companies of Lockheed Martin (e.g., General Electric-Aerospace Group; Martin Marietta) performed their basic research in numerous ways. Basic research for General Electric-Aerospace Group was done at General Electric's Corporate Research and Development Center. Basic research for Martin Marietta was contracted to research corporations such as Sarnoff Laboratories, while the company used its own advanced technology laboratories for applied research. In 1992, a five-year commitment for research funding at General Electric's Corporate Research and Development Center was made to General Electric as part of the General Electric-Aerospace Group sale to Martin Marietta. Three years later, the merger with Lockheed occurred. The desire to leverage General Electric's world-class research source toward Lockheed Martin's needs led to a great opportunity ... Shared Vision: Research and Development Funding.

Shared Vision: Research and Development Funding allows Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to leverage its investment dollars for accomplishing basic research and development. The original five-year research commitment has turned into a close-knit agreement between Lockheed Martin and General Electric as non-competing companies. This relationship enables them to share the costs of research and development, while gaining new technologies from basic research programs. Each company develops a business case that shows when and how a technology is needed to further their interest. Each program is defined by a Statement of Work, and often is coordinated with other technology development efforts (e.g., Internal Research and Development [IRAD], Contract Research and Development [CRAD], research grants). Research then begins. The companies also develop a task plan with measurable milestones, and review them on a monthly basis to determine the progress and results. The results are posted on General Electric's Integrated Data Environment Vault for easy access.

The co-investment by Lockheed Martin and General Electric allows more total research to be accomplished with less investment, and the results have the potential of bringing new technology to defense and commercial markets. An agreement between the companies gives Lockheed Martin first rights to patent the research. If this right is declined, General Electric can then patent the research if desired. But no matter who initiates the patent, both companies benefit as neither pays royalties to the other on the patented technology. Shared Vision: Research and Development Funding works best when both companies keep their research focused on mutually beneficial product and market insertions. Each concentrates on game changing technologies with a strategy to transition the technology to production. With the success of this co-investment, Lockheed Martin has expanded this type of program to Sandia National Laboratories.

Signal Integrity

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems utilizes Hyperlynx simulation techniques to surface signal integrity problems before they occur. The company has realized a significant cost and schedule savings on new designs and solved signal integrity issues with old designs.

In the past, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems had no formal practice dealing with signal integrity issues. Only guidelines and formulas from past experiences existed, with minimal or no evaluation in the laboratory environment. Problems were fixed as they occurred on the test floor or system, resulting in board and nest rework; design changes; and additional cycles through layout, fabrication, and test. Today, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems uses Hyperlynx simulation techniques to determine signal integrity problems before they occur.

Signal integrity begins with early evaluations as part of the design process. Simulations of signal integrity problems are determined prior to drafting efforts for board layout. Transmission line effects, impedance discontinuities, and crosstalk effects are found early in the design process. Drafting starts with place-and-route constraints being well defined. Using Boards, printed circuit board (PCB) designs are evaluated after drafting, but before fabrication

to eliminate transmission line, crosstalk, and electromagnetic interference (EMI) problems. This approach points out corrections which will be required on the backplane or other modules that interact with the module being simulated.

To test the new approach, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems employed signal integrity simulations to evaluate new designs, and the results were used to perform board layouts and backplane design configurations. After the company developed and built these designs, actual measurements were taken to compare the signal integrity with simulated results. These comparisons showed excellent correlation of simulation to actual signal effects found. The design resulted in minimal overshoot, undershoot, reflecting, and ringing. This process was performed on multiple 72-bit, 66-MHz buses as well as 33-MHz and 66-MHz clocks and signals. For clock signals at devices across all boards and the backplane, measured skews were typically less than one nanosecond. The new clock distribution approach was also evaluated and used. The backplane operated at 33-MHz for 11 interconnected modules. Pre-layout simulations of modules and the backplane were performed along with post layout simulations. No crosstalk problems occurred on the modules or in the nest and, to date, no signal integrity problems have been found.

Using the Hyperlynx simulation on old designs to fix problems was the next test. An existing design was evaluated for signal integrity and many problem areas were detected. Predetermined problems of ringing of unterminated backplane interfaces caused system test failures. Coupling onto other buses caused false data transitions. Failures were intermittent which surfaced late in the integration phase. After modeling with Hyperlynx, the company captured detailed printed wiring board (PWB), wire, and circuit characteristics from the interface modules and the backplane. Simulations correlated closely with measurements in the test, and provided a basis for termination methods and values. Timing analysis was performed at critical interfaces using simulated propagation delays for modules and backplanes. Module setup and hold times were projected at the connector for system debug support. Crosstalk was also evaluated during artwork revisions, and critical signals shown to be at risk were re-routed. Stack up of multi-layered boards were modified to reduce impedance mismatch between layers and reduced the crosstalk levels. Risks of rework, after layout test and integration, were minimized with the ability to evaluate complex modules; backplanes; stack up; modules in the backplane environment; and multiple module operations and interconnects.

The signal integrity process enabled Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to shorten the module and backplane design verification time frame. No additional schedule or costs occurred during or after integration and test. The approach also resulted in less risk associated with signal integrity in end-item systems. The company realized a first-time success on five module types and backplane interconnect.

Test

Micro Electronic Circuit Test Facilities

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems significantly decreased its testing time and costs for solid-state microwave modules by implementing fully automated, integrated test stations. The result is an extremely fast test platform that realizes minimal cycle time and high throughput on a completed device.

Previously, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems used multiple, rack-and-stack test platforms to perform numerous test dynamics. This approach required a lot of floor space, long test cycle times, considerable hands-on manipulation and intervention by the operator, and high recurring and non-recurring efforts for new devices. As the micro electronic circuit (MEC) production rate increased, the company needed a new method to handle the increase in test loads. The goal was to initiate a works-in-a-drawer, radio frequency integrated circuit-based station capable of multiple path, dynamic, and versatile specification testing with high speed on a single, two-port platform.

In 1991, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented a fully automated test station which reduced the average test time from eight hours to ten minutes per transmit/receive (T/R) module. In 1998, the test set was upgraded by using radio frequency integrated circuit components, which lowered the average test time to one minute per T/R module. Today, the MEC Test Facilities employ fully automated testing of various types of solid-state microwave

modules on a single platform. All test stations are housed in radio frequency-shielded rooms, and are equipped with a probe station for on-circuit troubleshooting. The integrated test stations are fast, flexible, and can test approximately 1,500 parameters in four fundamental T/R areas: noise figure; transient power; receiver gain; and differential phase.

Each integrated test station costs approximately $1 million. However, the savings in operator work hours recouped the cost of the station on the first project and, since then, the stations have been used on several projects. Additional benefits of the integrated test stations include reduced floor space requirements, wide dynamic range in frequency and power, and increased flexibility through software controlled test operations. Scheduled improvements to the MEC Test Facilities include increased flexibility and more user-friendly software, with a goal of greatly reducing the Facilities' research and development cycle time in support of new business proposals.

Production

Aegis Standard Review Board

The Aegis Standard Review Board is responsible for the Aegis Computer Program Standard Manual. By implementing a Change Management Database and a web-based system, the Board improved the processing cycle time and communication of approved modifications for the manual.

The Aegis Standard Review Board (ASRB) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is a multi-functional review board that facilitates process improvement changes to the Aegis Computer Program Standard (CPS) Manual. This manual contains a uniform set of processes used to assure that Aegis computer programs are of the highest quality and meet the customer's requirements and expectations. The manual also defines the processes and standards governing development, test, production, and life cycle support of the Aegis Weapons System (AWS) computer programs. ASRB is chaired by the Software Quality Assurance Manager, with the remaining membership coming from Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, government, and subcontractor activities. The Board is responsible for generating the Aegis CPS Manual, approving any change requests, recommending modifications, and communicating with process stakeholders.

Previously, change request forms to modify the Aegis CPS Manual were prepared manually and submitted to the Board for action. Anyone involved in developing software for the Aegis system had to maintain an up-to-date copy of the manual and conform to the standard processes. Changes approved by the Board were forwarded to the process managers for their approval. Accepted modifications were then bundled together for periodic release to all manual holders. The overall process often took several months for a change to be distributed.

In 1999, ASRB improved its change request process by developing a Change Management Database and a web-based system. Potential changes to the Aegis CPS Manual are now submitted and processed electronically. Accepted modifications are no longer bundled together for release, but instead are made available individually as soon as they are approved. Users are notified of all changes and updates via the web-based system. The web site also provides users with an on-line version of the Aegis CPS Manual, as well as access to Board meeting minutes and agenda, metric reports, and membership information.

Since implementing the Change Management Database and web-based system, ASRB has reduced the processing cycle time for modifications to approximately 30 days. This major improvement grew out of the Board's commitment to continuous improvement. Additional benefits include the promotion of process consistency and maintenance of process control through team participation.

Combiner Test Slip-on Terminations and Adapters

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, in conjunction with a connector vendor, developed a new slip-on connector that replaces the screw-on connectors previously used to test combiner. The new connector eliminates the screw-on and torque requirements of the previous method, producing a 50% reduction of the touch labor.

Testing and tuning of combiner is one step in the assembly process of one of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' major products. Under the previous method,

attaching the testing hardware was extremely labor intensive. Individual ports were required to be tested, while all other ports were terminated. This approach required each port to be fitted with a screw-on connector that had to be carefully tightened to a specified torque reading. Every measurement required unscrewing two ports, attaching the test cable to the next port, and then re-torquing. A single shipset had almost 300 combiners and each required multiple connections per test procedure. The process involved reading the baseline test results, tuning the combiner, and then retesting. The average combiner is tested 2.5 times, requiring about six hours per combiner. The goal was to reduce the combiner test cycle time, while providing repeatable and reliable phase data.

Working with a connector vendor, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems successfully developed and implemented a new connector which can be pushed onto the ports, significantly reducing the labor required for screw-on connectors. The new connector was incorporated in a 50-ohm Slip-on Termination and a Slip-on Through Adapter with low return loss. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems received the first batch of new connectors in January 2001.

The new slip-on radio frequency connector meets specifications and reduces combiner test cycle times by eliminating significant labor content when performing multiple repetitive connections. Figure 2-2 shows that the improved test method is producing significant results. Combiner test touch time has been decreased by more than 50%, resulting in an estimated savings of 1,200 hours per shipset. The method also produces verified measurement data that is repeatable to the previous screw-and-torque method.

Emergency Response Team

The Emergency Response Team provides response services for hazardous material spill events and health-related situations within Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, and operates as backup resources for local rescue units. The team's average response time of 30 seconds contributed to saving two lives in 2000.

Safety concerns for employees in the early 1970s created the hazardous material (HAZMAT) arm of the Emergency Response Team (ERT). In 1977, the medical arm of the Team was established. The success of these units enabled ERT to expand and provide employees at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with additional services including medical treatment, fire response, chemical/spill cleanup, high angle rescue, and confined space monitoring.

This advanced team of well-trained employees has created a benchmark program for other businesses to imitate. Using well-equipped, mobile HAZMAT spill response carts and health emergency lockers strategically placed throughout the facilities, ERT ensures immediate response time to any on-site emergency. On-going training, cross

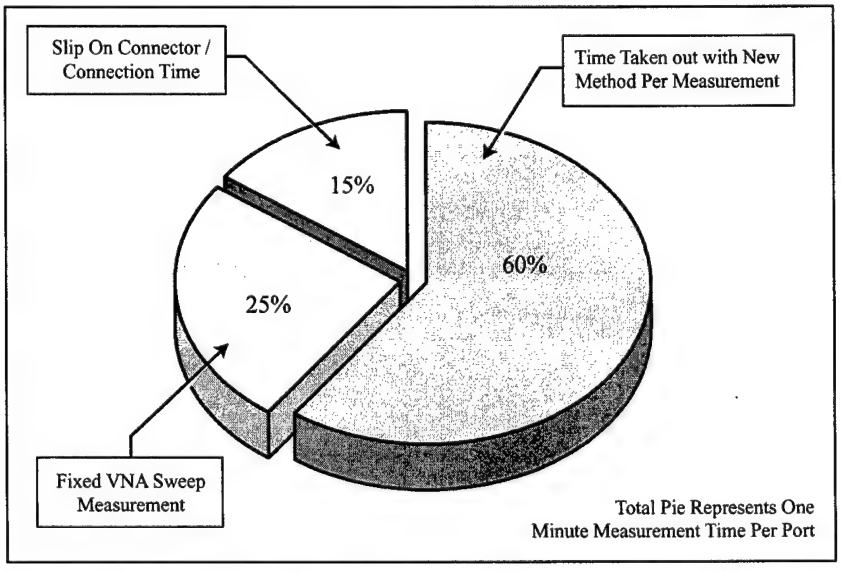


Figure 2-2. Combiner Test Labor Reduction

training, and situation drills keep this professionally dedicated team of experts ready for all situations. In addition, all employees at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems are trained to dial 7777 in the event of an emergency. If necessary, county Emergency Medical Technicians are contacted; however, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' ERT consistently responds within 30 seconds.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems continues to aggressively work toward ensuring safety in all situations. Employee training extends into the community through volunteer efforts of the company's employees. ERT handled more than 55 incidents in 2000, and is attributed to saving two lives by utilizing defibrillators.

Ergonomics Program

The goal of the Ergonomics Program is to reduce work-related musculoskeletal disorders known as ergonomic injuries. Since implementing the program, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems significantly reduced its worker's compensation costs and is providing a better working environment for its employees.

Previously, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems handled work-related ergonomic injuries by just treating OSHA recordables. This approach resulted in high worker's compensation costs, high OSHA recordables, low employee morale, and poor worker efficiency. To resolve this situation, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established an Ergonomics Program in 1995.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems first conducted a risk assessment of all processes. Here, the company eliminated some tasks in high-risk processes through redesign, and worked with methods engineers on the remaining tasks. Early intervention through the combination of medical management and workstation improvements also produced significant results. Employees are provided with the proper tool before problems arise and receive training on new equipment that is purchased. Communication is an important aspect of the program regarding employee awareness. Among these venues are brown bag discussions, ten-minute health sessions, and newsletter articles. In addition, the company set up an Intranet web site dedicated to ergonomics, which provides employees with links to health articles, ergonomics news, workstation information, and exercises. To avoid individual work center financial restrictions, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established a separate budget for ergonomics. Job rotations were also incorporated to eliminate long-term repetitive stress injuries, thereby providing an additional benefit of increased workforce flexibility for changing production requirements.

Since implementing the Ergonomics Program, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced its worker's compensation costs and OSHA recordables; improved employee morale; and increased worker efficiency. Employees now identify discomfort early, so it can be addressed before repetitive stress injuries become a problem. The company has dramatically reduced the number of lost workdays resulting from ergonomic injuries. Approximately 8,000 ergonomic-related lost days were reported in 1992. By 1998, this number dropped to zero and continues to remain very low.

Household Hazardous Waste Collection

Working with local officials, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established a Household Hazardous Waste Collection Program for employees and local residents. The biweekly event provides participants with environmental education and an accessible site for disposing hazardous chemicals. The cooperation of state and local environmental agencies provided sustained ability to the effort.

Previously, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems sponsored a once-a-year household hazardous waste (HHW) collection day. Wanting to improve this process and help reduce pollution in the local community, the company decided to revise its efforts.

In October 2000, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, in conjunction with Burlington County officials, established an HHW Collection Program. Each month, the company sponsors two one-hour sessions where employees and local residents can bring hazardous waste for proper treatment/disposal. Volunteer employees (supervised by trained Environmental Services employees) greet participants, identify collected waste, combine similar waste, and store waste for collection. Types of waste accepted include latex and oil based

paints; liquid and solid pesticides; waste oil; gasoline; kerosene; flammable aerosol cans; lead acid and alkaline batteries; flourescent lights; and corrosive liquids. The collection shed located just outside the security gates at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is grounded for explosion safety and features a large containment tank, submerged below the floor, to capture accidental spillage. State and county officials worked together with Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' Environmental Services to permit this beneficial community program. Collected waste is shipped by licensed transporter via bill of lading documentation to the Burlington County HHW Collection Facility for final determination.

The HHW Collection Program conforms to the company's environmental, safety, and health policy as well as ISO-14001 and New Jersey Department of Environmental Protection regulations. The program is the first of its kind in the state. Employees and local residents benefit from environmental education and the opportunity to dispose of unwanted chemicals in an environmentally responsible manner. Employees strive to practice proactive environmental stewardship and share this ethic with the community. During the first three-quarters of FY01, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems shipped 23 55-gallon drums of hazardous waste.

Micro Business 21

The primary goal of Micro Business 21 is to assure a competitive advantage for Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems and maintain job security for its workers. The reward to the company has been a workforce with higher morale, fewer absences, and lower worker's compensation claims.

Micro Business 21 is the current phase in a series of initiatives developed by a partnership between Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems and one of its unions, IUE-CWA. These initiatives assure a competitive advantage for the company, maintain job security for workers, and provide operators with transferable skills as the culture continues to embrace change. Using process improvement tools, Micro Business 21 addresses key business objectives of customer satisfaction, cost reductions, training, and employee development. It is designed to support the company's efforts to achieve operating excellence, and to drive this philosophy to the shop floor level by maximizing employee ownership of their product.

Micro Business 21 requires the micro business teams to develop a Business Plan, support the initiatives by sharing ideas and communicating information, and be involved in a Process Improvement Project. The Business Plan discusses and explains each of the seven Malcolm Baldrige criteria: Leadership, Information and Analysis, Process Management, Strategic Planning, Human Resources, Customer Satisfaction, and Business Results. The teams support the initiatives by participating in Key Meetings. Process Improvement Projects are identified and implemented by each team. Micro Business 21 focuses on identifying goals and objectives that provide targets for success.

To date, all of the goals for Micro Business 21 have been met or are on target for year-end completion. The incorporation of flexible job assignments enable employees to obtain experience for future advancement, and allowed Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to reduce overall costs and improve product quality. All of these accomplishments were obtained with the objective of maximizing performance; increasing customer satisfaction; and strengthening the company's efforts in attaining new business.

Micro Business 1000

Micro Business 1000 is a stand-alone program aimed at achieving the 1,000 points available under the Malcolm Baldrige criteria. This productivity improvement effort is a joint management-union endeavor featuring employee involvement and empowerment. The effort has created a total cultural change throughout Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, and provides significant benefits to the company and its customers.

In the early 1990s, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems responded to the need to reduce costs by initiating a series of continuous improvement initiatives. These initiatives were based on the foundation of an agreement between management and the labor union. The agreement, negotiated after a major downsizing event, stated that no further downsizing would occur if the union agreed to obtain efficiencies amounting to 50% cycle time and 25% cost

reductions. Through the use of productivity improvement programs, these goals were obtained and followed up with new goals: 40% reductions in defects and scrap. The initiatives have gone through five phases since 1992 and each time, the stated goals were accomplished.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems began planning the Micro Business 1000 phase in 1995 and fully implemented it in 1997. The goal of the current phase is to achieve 1,000 points available under the Malcolm Baldrige criteria. This voluntary participation program is implemented through a structured organization that is tailored to meet the program's specific needs. Overall direction is provided by a steering committee composed of the company's senior leadership team, union executive board members, and support operation members. The principal focus of the concept is based on teaming efforts to maximize employee involvement and empowerment. Accomplishment of the goals resulted in a training manual being developed for all team members. This manual is structured around the seven modules of the Baldrige criteria and includes descriptions, definitions, and criteria for achieving the 1,000 points.

The management/union team also developed "can-do" and "can't-do" guidance, which continues to evolve. The guidance addresses various topics such as team organization, manpower schedule, opportunities for new business, hiring/firing, choosing suppliers, pay scales, ethics, supervisory administrative functions, cost control, work in process (WIP), and deviations from the process. Currently, 16 Micro Businesses are working through the seven modules toward earning the Baldrige 1,000 points. These points are awarded on a module-by-module basis, and each team member can earn a $1,000 bonus for achieving the goal. The operation of each Micro Business consists of:

- Being trained in each module one at a time
- Applying criteria to its own business
- Demonstrating proficiency to the criteria
- Receiving assessment to the criteria
- Progressing to the next module
- Re-validating accomplishments

Since implementing Micro Business 1000, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has insourced several functions (e.g., analog/chassis/wave guide modules, power supplies, advanced processor cabinets) which previously were outsourced. The company also developed a Micro Electronics Center and is implementing a high density interconnect (HDI) facility. Shop floor employees now command leadership roles. Workers understand the business process; participate in running the business; and are compensated for their achievements. Each Micro Business team develops metrics to measure its work center as its own business. The bottom line of these continuous improvement efforts is a major cost reduction for the customer, even while order quantities have been reduced.

Pin in Paste Dual Technology

Pin in Paste Dual Technology is an efficient method for manufacturing circuit card assemblies that require both through-hole and surface mounted components. This single assembly-line process is very consistent once the specific parameters are established and tuned for the equipment used.

In the past, the method for manufacturing circuit card assemblies (CCAs) that required both through-hole and surface mount components was time consuming and labor intensive. The assemblies were subjected to screen printing of their printed circuit boards (PCBs); placing and reflowing of the surface mount components; manually inserting the through-hole components; masking; and wave soldering. During wave soldering, an opportunity existed for temperature shock (stress) to be introduced into the process. In addition, the solder flux used required CCAs to immediately undergo a water wash step for cleaning. Inspections for workmanship defects and rework occurred after each component population step. In cases of double-sided circuit boards, the procedure incorporated repetitive loops for component population. When two different process lines were in operation, the repetitive loops created disruptions and delays for work in process. In 1998, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems redesigned its process so that CCAs, requiring through-hole and surface mount components, could be manufactured on a single assembly line.

The Pin in Paste Dual Technology is compatible with single-sided CCAs using PCBs up to 0.120-inch in thickness, as well as double-sided CCAs using PCBs up to 0.100-inch in thickness. PCBs are now printed via an automated solder paste printer capable of multiple sweeps. CCAs

are processed using a convection reflow oven in a nitrogen environment with an approximately 2°C/second temperature ramp rate. Multiple paste screens enable the Pin in Paste Dual Technology to be an efficient method for assembling CCAs requiring both through-hole and surface mounted components on the same assembly line. X-ray inspection is utilized to identify any internal voids. The assemblies meet the requirements of IPC J-STD-001.

A two-step printing may be required if CCAs require both through-hole and surface mounted components to be on the same side of the board. The printing would consist of one thickness of screen to print paste the surface mount components, and then a thicker screen to print paste where the through-hole pin connector is mounted. The process of milling the underside of the thicker screen, to avoid contact with the surface mount paste of the first print, protects the original paste while the thicker paste is printed at the connector holes.

The Pin in Paste Dual Technology utilizes many elements (e.g., no-clean flux, solder paste) which help reduce the process cycle time. The specialized screen printing mask allows non-wash processing of many PCBs, which eliminates the wave soldering and washing steps. The gradual heating of CCAs through the convection solder reflow ovens decreases the possibility of introducing temperature shock. The single assembly line approach streamlines the manufacturing process and makes test failures easier to locate, thereby increasing feedback and reducing rework. Since implementing the Pin in Paste Dual Technology, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced its cycle time by 40%.

Productivity Improvement Projects

Beginning in 1998, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed and implemented Productivity Improvement Projects. The process for these projects consists of a simplified structure maintained in a comprehensive database with supporting documentation directly linked to each project.

In the early 1990s, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems defined a need to continuously improve its existing processes. Various projects were initiated and implemented, rather sporadically, on a case-by-case basis.

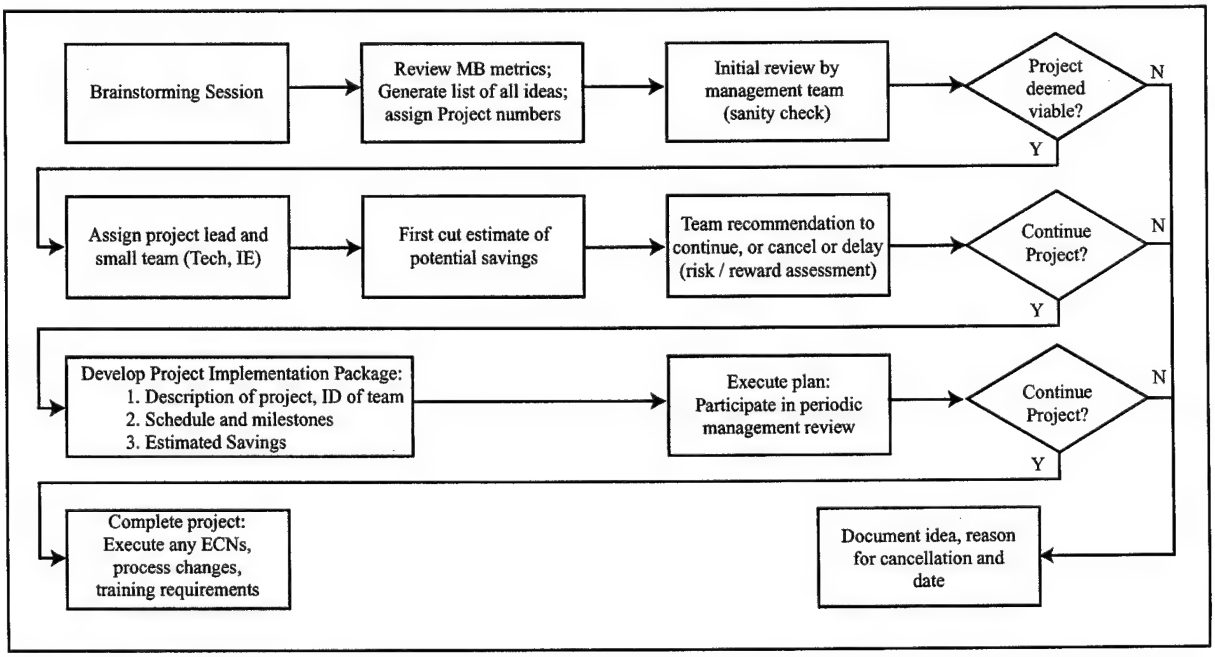


Figure 2-3. Process Flow

Others were undertaken as a reactive approach to resolve production/quality issues. Increasing competitive demands and tightening shop budgets drove the need for a more structured approach. Beginning in 1998, the company developed goals for a refined and revitalized approach with a focus on proactive-driven improvements and cost reductions.

The Productivity Improvement Projects include renewed planning, improved reporting structure, and better capture of improvements versus baseline. The approach utilizes the company's strong experience base, with the Technical Support Team and Operations Management initiating and facilitating brainstorming sessions in selected Micro Businesses. The initial step involved prioritizing the Micro Businesses and systematically working through the list, beginning with the highest priority. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems formed multi-functional teams to focus on non-value added operations, rework, and scrap. The company also developed a simplified process flow to facilitate the new approach (Figure 2-3), and a comprehensive database to support the entire operation from initiation through implementation and benefits tracking. The Productivity Improvement Projects take advantage of the tools and concepts offered by Lean and Six Sigma systems.

Since 1998, more than 100 project ideas have been captured with 40 implemented to date. Some of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' most significant projects include Concurrent Power Divider Testing during Anfast Testing; Tin/Lead Plating Elimination on Phase Shifter Connectors; Elimination of Epoxy Staking on Power Divider Subminiature Assembly Connectors; Reduction in Anfast Scanning Cycle Time; and Development of Push-on Combiner Test Connectors.

Transmit/Receive Module Assembly

Since establishing the Micro Electronic Center, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has improved the efficiency, quality, and throughput of manufacturing its transmit / receive modules. The Center features automated, in-line work cells that have a 40,000 module production capability, expandable to 150,000, per year on a two-shift basis.

Previously, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems used a manual assembly facility to manufacture transmit/receive (T/R) modules. The result was high touch labor rates per module, long cycle times, and high defect rates. In addition, high volume projects like the Counter Battery Radar (COBRA) contract for the European Consortium, requiring 60,000 T/R modules, drove the need for an automated facility. The solution was the Micro Electronic Center, a low cost, flexible, automated facility that could handle multiple projects simultaneously.

Designed with the latest state-of-the-art equipment, the Micro Electronic Center was Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' first paperless work center. Its ability to build the prototype, pilot, and production all on one line with one set of tooling ensured a high success rate. The automated, in-line work cells include epoxy dispense, component placement, epoxy cure, plasma clean, wire bond, bake out, and resistance/laser seam seal. The Micro Electronic Center features a 40,000 module production capability, expandable to 150,000, per year on a two-shift basis.

Since establishing the Micro Electronic Center, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems improved its efficiency, quality, and throughput in manufacturing T/R modules. The automated work cells also minimized clean room contamination and reduced costs. Employee interaction is primarily required for inspections. The Micro Electronic Center has enabled the company to reduce touch labor rates by 78%; decrease cycle times by 50%; and increase yields by 10%.

Logistics

Aegis Commercial-off-the-Shelf Technology Family Analysis and Selection Tool

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed an all-encompassing strategy for dealing with the complexities found in today's commercial-off-the-shelf acquisition environment. The Aegis Commercial-off-the-Shelf Technology Family Analysis and Selection Tool leverages the entire program community for risk mitigation and optimal system design.

Historically, the Aegis design process at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems incorporated commercial-off-the-shelf (COTS) equipment based on performance characteristics and acquisition cost. In recent times, this approach has become problematic due to the considerable insertion of COTS equipment, and has been exacerbated by conditions in which final product fielding typically occurred five years after design-based selection. Employing only two discriminators made the program extremely vulnerable to the risks of technological change, company viability, and diminishing manufacturing sources (DMS). Furthermore, late involvement of logistics staff in the design/COTS process led to major supportability issues and extravagant replacement costs. In 2000, the Lifetime Support Operations at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Aegis COTS Technology Family Analysis and Selection Tool (ACTFAST).

This relatively new tool and process assess total life cycle concerns in COTS equipment selection process. ACTFAST addresses acquisition focus areas of technical/performance, program management (e.g., development; production; operations, support and training), total relative cost, and roadmaps (multiple baselines; viability; market/technology trends). The method requires only a minimum amount of information to start, and involves a three-phased approach consisting of technology identification, vendor selection, and end-product choice. During the Integrated Product Team (IPT) process, discriminative questions lead to discriminatory categories which, in turn, require data collection. The acquisition information collected is then refined, weighed, and assessed by the IPT prior to making a selection. The IPT consists of representatives from the Navy Fleet, Program Office, Production Engineering, Manufacturing, Sourcing, Lifetime Support Operations, industry, and laboratories.

ACTFAST creates a forum in which roadmaps from Engineering, Sourcing, and Lifetime Support Operations are compared and aligned on a proactive basis with customer buy-in. This type of total community involvement promotes robust equipment decisions, efficient COTS equipment selection processes, and superior equipment design.

Management

Automated Engineering Change Notice/ Problem Sheet System

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the Automated Engineering Change Notice / Problem Sheet System as a workflow tool for creating, reviewing, and tracking engineering changes and manufacturing issues in a paperless environment. This system allows for complete visibility of the process at all times, and provides the metrics necessary to properly evaluate the success of the process.

In the mid-1990s, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems converted its engineering change notice (ECN) process from a manual, labor-intensive, paper process to an automated, computer-based process. This change allowed the company to better track the flow of its ECNs and reduce its approval cycles. In the late 1990s, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems further refined this process by creating the Automated ECN/ Problem Sheet System, an electronic workflow tool for creating, reviewing, and tracking engineering changes and manufacturing issues in the design and manufacturing environment.

ECNs are formal mechanisms for revising released engineering drawings. Problem sheets are formal mechanisms for documenting issues with engineering or process documentation. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems wanted to tie together the databases of these related, but separate mechanisms. The goal was to replace the paper process across various organizations with a single electronic process and to streamline the review and approval process. As a result, the company developed a common tool for creating documentation that still met the varying needs of its numerous users.

The Automated ECN/Problem Sheet System provides Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with an automated tool for creating, processing, and monitoring ECNs and problem sheets in engineering, manufacturing, program management office, and sourcing depart-

ments. Standard and custom review screens give employees the ability to develop meaningful metrics of their processes. In 2000, more than 6,600 documents were processed under this system. The company has also significantly reduced its total cycle time (problem sheet investigation, analysis, ECN generation, and approval) to approximately nine days.

Backfit Programs Test Facility

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established the Backfit Programs Test Facility to confirm that equipment upgrades are properly configured and operational prior to shipboard installation. Most upgrades are done in a land-based environment which can identify and resolve equipment failures and issues, without impacting a ship's overhaul schedule.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is the prime contractor for the Aegis Weapons System (AWS), and is responsible for commercial-off-the-shelf (COTS) equipment upgrades (or backfits) to the ship. The previous practice for handling backfits was to send the equipment directly to the ship, requiring the company to perform COTS equipment upgrades based on the ship's availability at the waterfront. Upgrades in a ship environment raised a number of issues that impacted cost, schedule, and risk. Typically, a team of workers was assembled together and sent to a ship. They were expected to install the equipment; test and troubleshoot it; and identify and resolve any failures — all *without* impacting the ship's overall schedule. The practice took several weeks to complete, sometimes required additional support, and seldom was accomplished without interruptions. Driven by these inefficiencies and capitalizing on a very successful Forward Fit AWS production program, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the Backfit Programs Test Facility.

This test facility removes the majority of the backfit processes from a ship environment to a land-based environment. The facility is equipped with many pieces of the actual equipment in the ships, as well as simulators and emulators to support the level of testing, troubleshooting, and diagnostics required to bring the equipment to an operational level. The equipment is brought directly to the Backfit Programs Test Facility rather than shipped to the waterfront. The test facility provides the required firmware baseline, operating environment, IP addresses, configuration updates, and test requirements as configured on the ship. The facility can validate the equipment performance by bringing all ship systems into play. Additionally because the facility is located close to Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, the Backfit Programs Test Facility can leverage its expertise, procedures, and skill mix.

The Backfit Programs Test Facility provides confirmation that equipment upgrades are properly configured and operational prior to shipboard installation. The facility identifies and resolves equipment failures and issues without impacting a ship's overhaul schedule. By performing most backfit processes in a land-based environment, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced labor costs by 50%. Overall program risk is now mitigated. The Backfit Programs Test Facility can tap into a wide array of resources from Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems and the previously implemented Forward Fit program. To date, three systems have been processed through the facility, installed on the ships, and are operating successfully.

Consolidated Purchasing

Lockheed Martin created three consolidated purchasing organizations, one of which is the Material Acquisition Center Mid-Atlantic Region at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. As a result, the corporation has increased the speed, agility, and services of its acquisition process while improving product quality and reducing costs.

In the past, each individual business unit of Lockheed Martin maintained and operated a complete and independent purchasing department. Few common practices spanned across these units, resulting in inconsistent sourcing and quality practices. Opportunities for increased buying efficiencies and overall cost effectiveness were often lost. Multiple organizations increased the number of

suppliers as well as variation in the products. Lockheed Martin resolved this situation by consolidating the business units into three purchasing organizations, one of which is the Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems.

MAC-MAR provides full service sourcing for Lockheed Martin and some non-Lockheed Martin companies. The sourcing services include direct, major subcontract, and indirect buying; supplier management; technology engineering; receiving; supplier quality assurance; inspection; freight management; cost estimating; and compliance. The role of MAC-MAR goes beyond basic research/new production development, through production, and into lifetime support after the product reaches the market. In addition, MAC-MAR actively participates in the shared corporate goals of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems such as Lockheed Martin 21 Operating Excellence, the Six Sigma Program, and Information Technology (IT) E-Commerce. Consolidation is also making it possible to do more within the Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' acquisition community such as technology roadmapping, global supplier base, and systems integration.

Additional services and buying centers are being developed for 2001 and beyond. These services include material cost estimating, field quality, freight-in, assessments, and subcontract agents. Commodity, indirect, and IT buying centers are also beginning to emerge, and MAC-MAR is initiating an automated buying process. A consolidated purchasing approach provides tremendous leverage with suppliers while greatly reducing the cost of doing business. Since being established, MAC-MAR has improved total manpower productivity by 26.4% over four years; improved material quality by 128%; obtained the highest buyer productivity in Lockheed Martin; and reduced overall procurement costs by 32%. The administrative surcharge alone on acquisition services dropped from 10% in the early 1990s to 5% in 2000.

Continuing Education Program

The Continuing Education Program at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems fosters a cost-free continuous learning environment in partnership with the local community college. The program provides employees with the opportunity to enhance their professional skills knowledge, and provides employees and their spouses the opportunity to receive personal development training.

Proactively established by an employee committee, the Continuing Education Program (CEP) is an after-hours, cost-free training and development program aimed at providing professional and personal development opportunities to employees at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. The personal development training is also available to employee spouses. This dynamic program is managed by an all-employee, cross-functional committee in partnership with Burlington County College, a local community college, for administrative support and instructor validation and payroll.

All of the instructors in this program are employees of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, and are recognized as subject matter experts (SMEs) in their respective areas. The company pays their salaries for teaching the courses. Prior to being selected, potential instructors receive training in teaching techniques and are certified by the local community college. By having in-house SMEs teach the classes, the company ensures that the subject is applicable to the needs of the students. Professional development courses are those which meet the business technology needs of the employees. Personal development courses are those requested/suggested by employees such as retirement planning, CPR, financial planning, and quick-fit exercise classes. All training is conducted after working hours for the benefit of the employees, spouses, and instructors. Fall and Spring semesters consist of 10- to 12-week sessions. The committee reviews and selects the course offerings for each upcoming semester.

Since CEP's inception over 15 years ago, more than 900 employees and their spouses have participated (an increase of 450%), and course offerings have increased from 10 to nearly 30 courses per semester. The continuing growth and success of the program contributed to Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems winning the New Jersey Quality Award in 1994, and to two Malcolm Baldrige site visits in 1997 and 1998.

Eight-Step Process Improvement Program

The Eight-Step Process Improvement Program, an effective continuous improvement tool applied to supplier quality management and development, recognizes that significant risk can be mitigated before adverse trends develop. The program focuses on process control and sharing of quality techniques, and can be applied at any time during the production cycle.

In the past, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems used traditional approaches (e.g., production readiness reviews, qualifications prior to production) for supplier quality management and development. During production, a reactive system monitored the supplier's quality performance and implemented corrective measures after trends were identified. Although somewhat effective, the company did not study the processes in detail nor optimize the opportunities for making improvements. Readiness reviews often lacked the thoroughness required to study in-depth process flows and preparedness for new/revised products introduced into the system. Reactive systems required fixes after significant damage had already been done, typically impacting product cost, quality, and delivery at a much higher level than if adverse conditions were corrected early in the production cycle. Seeing an opportunity for continuous improvement, the Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Eight-Step Process improvement Program in 1998.

The Eight-Step Process Improvement Program follows a detailed process flow that focuses on critical suppliers, materials, and processes; uses analytical tools to identify supplier trends; identifies critical manufacturing and/or part processes; and employs process surveillance to monitor risk areas. With the help of input by the business units, key suppliers are selected for review under the program. MAC-MAR assigns a lead engineer to facilitate a team of three to six people for each supplier, which then sets the eight-step process into motion. Team composition is personnel from other business units who have expertise in the products/processes related to the product to be delivered. The team uses various purchasing and performance databases to develop Pareto Analysis charts for review, and has access to the supplier to document, review, and analyze process flows. From these analyses and reviews, the team develops supplier action plans and requirements. The supplier makes the prescribed changes and the team monitors the performance. The combined progress of all the suppliers selected for the program is then charted to reveal the total impact of the Eight-Step Process Improvement Program.

In 2000, 93% of the 57 key suppliers showed performance improvement. By the first quarter of 2001, 96% of the 59 key suppliers showed performance improvement, all impacting various degrees of quality, cost, and delivery of their products to Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. The Eight-Step Process Improvement Program is part of a powerful suite of tools and techniques employed by MAC-MAR to improve supplier performance.

Electronic Contract Management Environment

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Electronic Contract Management Environment as a secure web site for storing and retrieving all documents essential to the contracts process. The searchable files provide immediate access, accurate information, and efficient version control to remote users.

Previously, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems stored all contracts files as hard copies in multiple, dispersed repositories. As more of the workforce began traveling or resided off-site, these paper files became more inaccessible. Other drawbacks were the burden of administrative support required to maintain hard copies, and the probability of inaccuracies or untimely retrieval. To resolve these issues, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Electronic Contract Management Environment (ECME), an electronic source for storing and retrieving all documents essential to the contracts process.

ECME uses a web-based integrated digital environment (IDE) to set up electronic file folders behind a firewall, which are easily accessible by registered users via Internet browsers. After converting key

hard-copy documents to an electronic format, these and existing Word-format documents were added to ECME's folders. Currently, more than 15,000 contractual documents are available to 300 users. Automatic document notification is done via e-mail. The robust search capability is always accessible anywhere to all employees with assigned access.

The on-line ECME provides efficient delivery and distribution of all key contractual data. The system promotes re-use of information by many parties, while eliminating the need to copy and e-mail documents. Version control is easy, and booking and reporting errors are vastly reduced. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has even provided limited customer access to IDE for both storage and retrieval at the company's discretion.

Employer of Choice: A Focused Approach

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Employer of Choice: A Focused Approach as comprehensive, multifaceted programs aimed at attracting new employees and retaining experienced ones. These programs focus on the achievement of business goals and objectives, as well as address key issues such as quality of work life, growth and development, diversity, and work / life balance.

In the past, efforts to address Employer of Choice programs were isolated, often departmentally focused missions. Today's workforce is seeking an improved balance between work and non-work activities, so the need for change became self-evident. In response, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed Employer of Choice: A Focused Approach as a way to attract new talent and retain experienced employees.

Employer of Choice consists of comprehensive, multifaceted programs, aimed at increasing the satisfaction level of employees and their overall effectiveness at work. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems identifies, develops, and implements policies and programs that support the achievement of business goals and objectives, as well as positively addresses key issues such as quality of work life, growth and development, diversity, and work/life balance.

Examples of Employer of Choice policies and programs include:

- Employee Development Subjects which include continuing education for both career and personal development; 100% tuition reimbursement for up to two courses per semester; a total knowledge network with hundreds of computer-based training courses; and a formal mentoring program to develop and retain high potential employees.
- Flexible Work Schedules allow employees to custom design a 40-hour work week to best balance their personal and business needs and commitments.
- Concierge Services provide personal services and professional expertise. This allows employees to satisfy personal needs while continuing to function productively at work. Services include buying cars, making personal travel plans, and booking hotel or restaurant reservations.
- Community Outreach Programs include Minorities in Engineering, Future Engineers and Scientist Outreach Program, Public Responsibility Team, United Way, Boy Scouts of America, Network of Volunteer Associates, and Hazardous Material (HAZMAT) Recycling.

Since implementing the Employer of Choice programs, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has attracted over 900 new hires in the past two business years and employee attrition is at its lowest in three years. The result is a workplace where employees are empowered to make decisions, where they feel included, and where they can play a significant role in the business while growing and developing to their full potential and successfully managing both work and personal commitments.

Employee Suggestion Program

A web-based Employee Suggestion Program is providing employees at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with a renewed interest in submitting beneficial suggestions. The program's comprehensive tracking system provides ease of entry, and utilizes extensive security measures to ensure the accuracy of the data without limiting the users.

In 1991, a formal employee suggestion process was implemented as part of a major effort to help reduce costs and improve products, safety, quality, facilities, operations, and sales. This process was the typical paper-based, carbon-copy system suggestion box that required manual handling for collecting, evaluating, and tracking employee suggestions. Looking for a new approach, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented a web-based Employee Suggestion Program in January 2001.

The Employee Suggestion Program features a Suggestion Tracking System that operates as a comprehensive tool for inputting, storing, evaluating, and communicating suggestions throughout the organization. Suggestors can submit their ideas on-line as individuals, co-suggestors, or in teams. The Suggestion Tracking System facilitates ease in submitting ideas via a fill-in-the-blank electronic format. The system automatically generates e-mail to notify the various functional departments. The goal of the Employee Suggestion Program is to answer each suggestion quickly, fairly, and accurately within 20 days. Once a suggestion is initially evaluated and selected, it goes to a Suggestion Review Board comprised of cross-functional members including management and union representatives. Every suggestion receives feedback of disposition and an explanation of the evaluation decision. Successfully implemented ideas can earn an award of 25% of the first-year savings for a team effort or 15% for an individual effort.

The Employee Suggestion Program's comprehensive tracking system takes advantage of the company's Intranet to ensure the accuracy of the data without limiting the users. Since implementing the program, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has received an estimated 30% to 40% increase in the number of suggestions. The following represents year-to-date metrics for 2001:

- 497 suggestions received
- 124 suggestions implemented
- $90,298 in tangible savings
- $29,870 awarded to suggestors
- $241 represents average award
- $12,888 in work center pool
- 55 suggestions in current backlog

Leadership 21

Leadership 21 operates as a business strategy to systematically advance Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' leadership capabilities. The program addresses the changing marketplace, the changing workforce dynamics, and the rapid expansion and application of technology.

Previously, development program learning opportunities for current and future leaders were provided by a variety of disconnected sources (e.g., local leadership courses, university programs, Lockheed Martin Institutes). In 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed Leadership 21 as a business strategy to systematically advance the company's leadership capabilities.

Leadership 21 addresses the changing marketplace, the changing workforce dynamics, and the rapid expansion and application of technology. It operates as a business strategy to gain a competitive advantage through employees; improve current and future performance and competitiveness; address cultural and leadership challenges; and attract, retain, grow, and motivate talent. The program is based on a well-researched Leadership Competency Model with six capabilities: building productive relationships, developing human talents, facilitating meaningful change, communicating on purpose, optimizing business processes, and making insightful decisions. Each capability is supported by 24 relevant competencies, all of which have assessment tools, feedback reports, development planning based on personal feedback, and development actions (e.g., training, self-study, rotational assignments). Additional features of Leadership 21 include an extensive leadership resource library made up of relevant books, CD-ROMs, articles, a mentoring program, and individual coaching. The program has been expanded to other sites within Lockheed Martin as the preferred Leadership Development Model, and is currently being considered as the Leadership Development Program of choice for the entire Lockheed Martin Corporation.

Leadership 21 is creating an environment that taps into the talents of every employee, improving productivity and profitability, and ultimately placing

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems in the best position possible to execute and achieve its long-range business strategy. Leadership 21 sharpens employee focus and direction; harnesses discretionary employee energy; fosters a learning environment; contributes to a common language and culture; enhances manager-employee relationships; and helps leaders proactively manage change.

Leadership Development Program

The Leadership Development Program helps ensure that future leaders of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems are fully trained in the business and operations of the company. This cadre of employees will contribute to the company's future competitive edge.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed and instituted a Leadership Development Program that is designed to attract, develop, and retain high potential professionals. The goal is to establish a pipeline of talent for future business and technical leadership positions within the company. Each of the five business units (communications, finance, engineering, operations, and human resources) in the company has an allocation that indicates the number of leadership development positions that they may have active at any given time. This allocation is based on the present and anticipated needs of the individual organizations.

The Leadership Development Program is an intense two- to three-year program offered to attract, develop, and retain future leaders who will contribute to the competitive edge of the company. Participants, along with their leadership mentors, develop a training plan that includes four to six rotational work assignments within the company. These assignments can be entirely within their functional areas (e.g., Finance, Operations) or be cross-functional rotations that provide a broader based experience. Along with the rotational assignments are educational opportunities such as further study to attain a Masters degree, Leadership Development Conferences within the company, specialized training to enhance technical skills, and strategic leadership skill training. The program allows participants to gain exposure to the Senior Leadership Team of the company.

Candidate selection for the Leadership Development Program is based on past performance of high potential and high performing individuals who apply or are nominated for participation. Each candidate undergoes several rounds of interviews and evaluations by senior management personnel of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. An application for admittance to the program can be made by new hires and existing employees. In the case of new hires, their past accomplishments, academic records, involvement in community affairs, professional affiliations, leadership potential, etc. are all taken into consideration.

Leadership 21 provides Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with a cadre of trained and dedicated personnel to lead the company into the future. Graduates of the program gain a good understanding of the business as well as cultural aspects of the company.

Lean and Six Sigma

Lean and Six Sigma is a structured process improvement methodology that significantly increases the involvement and effectiveness of employees in improving the systems they use to perform their work. The fundamental goal is to provide value through the eyes of the customer.

Six sigma deployment and lean integration has been an evolutionary process at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. The company used a manufacturing process focus up through 1998, a design focus in 1999, and a business processes focus in 2000. The Quality, Ethics and Mission Success Organization developed the strategy, implemented the plan, and coordinated the driving change across the business. Today, Lean and Six Sigma is a structured process improvement methodology that significantly increases the involvement and effectiveness of employees in improving the systems they use to perform their work.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems identified several key roles in pulling the Lean and Six Sigma methodology together, and it starts from the top. Figure 2-4 shows the overview of the process. A Senior Leadership Team (SLT) of 14 top execu-

tives provides visible support through programs and resources to drive overall change throughout the organization. Functional organizations select Management Points of Contact to be the focal point of Lean and Six Sigma (e.g., project measurements, performance, results) in their areas. These individuals manage and focus resources, concurrent with identifying key project opportunities. The company also uses Master Black Belts (MBBs), full-time employees who have significant experience in Six Sigma and Lean methodology in addition to change management leadership. MBBs implement program strategy; lead projects; facilitate improvement events; and provide training and mentoring for over 500 Black and Green Belt employees trained in the Lean and Six Sigma philosophy. The key focus areas are:

- Transactional Lean and Six Sigma which exposes sources of errors, rework, and non-value added steps.
- Manufacturing Lean and Six Sigma that prioritizes and eliminates the most costly defects.
- Design for Six Sigma that validates the availability of capability to meet customers' needs.

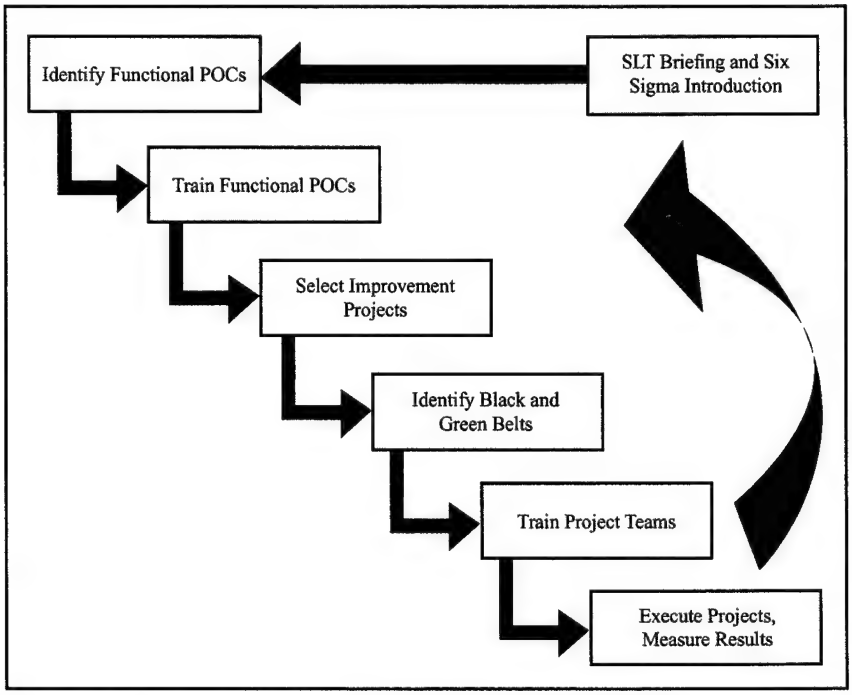


Figure 2-4. Process Overview

Training courses are integrated into the Lean and Six Sigma approach, including four to eight hours of Leadership Awareness; 120 hours of Black Belt Training; and 24 to 40 hours of Classical and Design for Six Sigma Green Belt Training. Monitoring and communicating performance are done through project performance metrics, engaging the Financial Department upfront and through monthly project performance reviews. Other elements are communications and recognition. Communication vehicles include pamphlets, business reviews, newsletters, roundtables, and Intranet web sites. Recognition and rewards include plaques, certificates, monetary awards, and give-away items (e.g., mugs, jackets, shirts).

The return on investment of Lean and Six Sigma techniques is directly proportional to the commitment of business leadership. These techniques aid Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems in providing effective tools to actively identify waste (e.g., defects, time) and remove it from work processes. After waste is removed, techniques for sustaining improved performance are implemented. The fundamental goal of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is to provide value through the eyes of the customer.

Manpower Analysis Process

The Manpower Analysis Process is a highly innovative way to forecast ship system manning requirements. The Process features two powerful simulation tools that successfully deal with the human equation aboard high-technology Navies.

Previously, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems derived its system manpower requirements from spreadsheet calculations that totaled the man-hour esti-

mates for operations and maintenance. This method was subjective and prone to considerable variation. To resolve these issues, the Lifetime Support Operations at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Manpower Analysis Process (MAP), a highly innovative way to forecast ship system manning requirements.

MAP introduces a virtual environment based on modeling and simulation that satisfies multiple high-level objectives. The process identifies system manpower requirements by creating a Preliminary Ship Manpower Document (PSMD); traces system requirements through to human tasks and roles to perform these tasks; provides trade-off information for making system staffing decisions; facilitates design recommendations for optimal staff utilization; and supports balancing between automation and human tasking. Simulation results are periodically checked against actual fleet observations, which includes direct input from ship system personnel.

The Total Crew Model (TCM) and the Watchstander Task Model are powerful simulation tools used in MAP. TCM effectively validates manpower analysis simulations to determine the adequacy of a proposed crew complement. Data from these simulations are used to determine if the assigned crew complement can successfully accomplish all underway operations and do so within acceptable fatigue levels. TCM considers the combined effects of crew size, watchstanding schedules, watch quarter and station bill (WQ&SB) assignments, and performance recovery rules. The process indicates crew saturation points for any sequence or combination of tasks. Input from crews is used to run more realistic, special event scenarios reflecting the upper limits of crew endurance. The Watchstander Task Model effectively validates manpower analysis simulations to examine watchstander workload during high-stress, realistic scenarios in the context of the conceptual system design. Data from these simulations are used to determine optimum manning requirements, and to identify areas where system automation will effectively reduce crew workload. As a result, manpower requirements are factored into the design phase early-on, significantly affecting the deployed technology. Model designs permit the simulation of any team size, task, or automation adjustment, which renders valuable feedback to system designers.

MAP provides Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with tactical and strategic implications. This approach has been applied to the U.S. Coast Guard Deepwater Program, the U.S. Navy Destroyer Duran-Ballen 21, the U.S. Navy Aegis Destroyer/Cruiser, and the new Norwegian Frigate. Directives associated with cost and technology incentives are leading to greater awareness and acceptance of MAP technology. This integrated process places Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems in an advantageous position with respect to the human/system needs of 21st Century Navies. Future ship staffing levels will be evenly matched and balanced with technology, permitting an optimal engagement in any given scenario.

Master Purchase Orders

In 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented Master Purchase Orders for its development programs. The process enables the company to stay competitive in the marketplace by obtaining material and services at pre-negotiated pricing without buyer intervention.

Previously at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, the purchasing process took up to 40 working days to move an order through material request completion, financial approval, direction to the buyer queue, buyer's completion of pricing and availability assurance, compiling a paper audit trail, expeditor's time to confirm and/or expedite material delivery, and delivery of material and/or purchases. In 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems set out to streamline its process by implementing Master Purchase Orders.

A requestor initiates a purchasing order by filling out a standardized reporting form, secured through the Intranet web site, to create a paper audit trail. Next is verification of the order to ensure that neither the expenditure limit has been exceeded nor that the period of performance has expired. After verification, the requestor contacts the supplier to obtain a written quote based on pre-negotiated rates, and electronically delivers the completed form and quote to the Material Request Analyst for processing. Data warehouse reports are used to provide tracking and verification through approvals, order placement, receipt by supplier, and delivery at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems.

Since implementing Master Purchase Orders, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced its procurement cycle time from 40 working days to just 24 to 48 hours. This process enables the company to obtain competitively priced materials and services; shortens purchase order placement time which helps keep programs on schedule; and reduces labor costs by decreasing buyer involvement in the purchases.

Operations Data Warehouse

In 1996, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the Operations Data Warehouse. This consolidated electronic database provides vital real-time, business critical operations data and metrics to engineers and managers.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems previously used an antiquated method of weekly downloading and printing of Production and Inventory Optimization System manufacturing data. The need for report flexibility, timeliness, and ease of data capture drove the company to develop a data warehouse software system. Developed in 1996 and deployed in 1997, the Operations Data Warehouse truly thrived in 2000 when countless user-defined, ad-hoc queries became a staple of management review for critical events.

The Operations Data Warehouse is an extremely powerful program that hosts endless data query possibilities for the user. It provides a repository of detailed and summarized data, drawn (weekly or daily) from operational or legacy systems, and is designed for analysis and decision support purposes. By viewing all data through one trusted data collection/distribution program, users are assured data consistency. Access to captured data provides capabilities to monitor production trends, desktop access to reports, and continued growth in information reporting and analysis. All data is easily manipulated via Microsoft Office (e.g., Excel, Access) and can be electronically transmitted to suppliers and customers to further reduce issue cycle times. The utilization of Hummingbird BI/Query (formerly Andyne GQL) proved to be powerful, but expensive to license for all users due to Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' overestimation of ad-hoc report generation. Pertinent information is available via the web for business-wide access, thereby further enabling productivity.

Since implementing the Operations Data Warehouse, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has eliminated several tons of paper reports which had been generated weekly. The database provides vital real-time, business critical operations data to engineers and managers. Additional data capture reports are easily acquired through this user-friendly tool.

Proposal Database

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Proposal Database to streamline the tracking of proposals from the Request For Proposal stage to submittal of the final proposal to the customer. The database allows for the coordination of all efforts within the process and the ability to track areas for improvement.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems previously tracked proposals by using a labor-intensive manual process that relied on the accuracy of several databases which were incompatible with one another. The databases

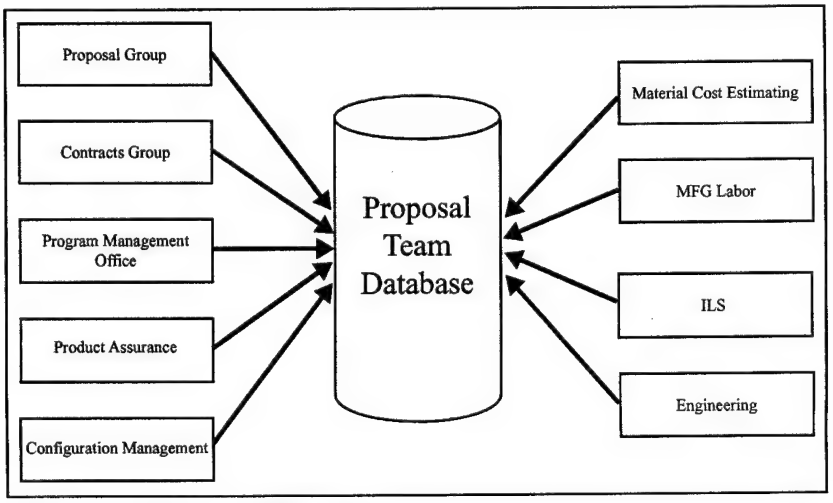


Figure 2-5. Proposal Database

were non-standard and typically had incomplete information on activities. The Contracts Group initiated an internal proposal request based on the Request For Proposal (RFP) received from a potential customer. A dedicated Proposal Group then requested cost, pricing, delivery, and other information from various operations groups; attempted to roll up the information into one package; and forwarded it to the Contracts Group. The result was long proposal cycle times and a difficulty in ascertaining various functions. In late 2000, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the Proposal Database.

The Proposal Database (Figure 2-5) standardizes the information throughout proposal activities. All entities work from the same criteria set forth in the RFP, eliminating redundancy of information and input errors that previously occurred. All Operations Groups can easily access and retrieve information from this on-line automated database. The Proposal Database features a mechanism to track various tasks associated with the proposal cycle and identify areas for improvement.

Since implementing the Proposal Database, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems reduced its cycle time for proposal preparation by 64%. The on-line database enabled the company to establish reporting capabilities for tracking proposal cycle information and improve communications among all team members in the proposal process.

Supplier Day Event/Symposium

To maintain effective supplier relationships, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems communicates its business plan and future initiatives to critical suppliers through a Supplier Day Event / Symposium. A well-designed 21-step process ensures effectiveness, a mission-focused theme, and top-level management participation to deliver the message and establish a solid business partnership.

Since the early 1990s, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has conducted symposiums to foster team building and two-way communications with its key suppliers. These symposiums allowed suppliers to stay informed of the company's business and strategic plans, learn about their role in the execution of these plans, and grasp the importance of making sound management decisions affecting the future of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems and themselves. Although some evidence existed on the lack of feedback and commitment by the suppliers, these symposiums helped in the overall relationship between the company and its suppliers. Right-sizing initiatives to improve its internal purchasing functions led Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to improve its supplier relationship and build upon the established groundwork. The Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Supplier Day Event/Symposium.

The revised format concentrated on total supplier commitment and unparalleled relationships among Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, the suppliers, and the customers. Based on lessons learned from previous symposiums, the event focuses on the effectiveness of the message to be delivered, face-to-face discussions, real-time feedback, and sharing the views of Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, the suppliers, and the customers. MAC-MAR also developed a vigorous 21-step process to execute and deliver the Supplier Day Event/Symposium. The process features an event Steering Committee, a realistic budget, working committees, and a post symposium follow-up. High-profile speakers; high-level customer management; and top-level managers from Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems are involved in delivering the message, participating in the exchange, and establishing a solid business partnership.

The first Supplier Day Event/Symposium, held in 2000, exceeded all expectations. Future events will be conducted every 18 months to two years. The theme selected for the event/symposium conveyed the importance of Lean Manufacturing with Six Sigma capabilities. As a result of the Supplier Day Event/Symposium, suppliers are reportedly addressing lean manufacturing initiatives or requesting training from MAC-MAR, thereby solidifying their commitment to Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems and its customers.

Supplier Kaizen Event

The Material Acquisition Center Mid-Atlantic Region at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems conducts the Supplier Kaizen Event for key suppliers. This on-site, two-day Kaizen training program focuses on administrative paperwork surrounding the expediting of items, thereby improving on-time deliveries, increasing communications, and reducing cost management.

In the past when faced with delivery issues by suppliers, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems often required the suppliers to manually expedite specific items, usually when they were already late. This reactive management approach caused schedule delays, added expense from work-around, and impacted material quality. In early 2000, the Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Supplier Kaizen Event. Kaizen in Japanese simply means *improvement*, and this type of methodology teaches that higher levels of performance can be achieved through an ongoing process of continuous improvement.

MAC-MAR proactively addresses delivery concerns with key suppliers by providing them with an on-site, two-day Kaizen continuous improvement training event. Its focus is to improve administrative paperwork surrounding the quoting, receiving, processing, and shipping of orders. The Supplier Kaizen Event features training in Kaizen methodology, process charting, self-assessment, brainstorming, problem identification, and developing action items. Actual implementation of the action items is left to the suppliers. The training is being presented at a rate of one to two suppliers per month, until all key suppliers have been trained. Key goals of Kaizen methodology is to involve the workforce in minimizing waste, shortening cycle times, and quickly communicating changes.

Improvements by suppliers became evident after several months following the Kaizen training. Of 11 suppliers who underwent training, each has shown on-time delivery improvements ranging from 8% to 107%, with an average improvement of 43%. These improvements translate to an overall improvement of 10% in on-time deliveries and an 11% reduction in late deliveries for Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. Additional benefits include improved communications and a reduction in cost management.

Technology Roadmapping as a Sourcing Tool for Concurrent Engineering

The Material Acquisition Center Mid-Atlantic Region at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has taken concurrent engineering to new heights with Technology Roadmapping. This innovative strategy integrates sourcing upfront in the proposal, design, and production processes.

Previously, sourcing was not a major stakeholder in upfront proposal, design, and production processes, even though procured material expense was 65% of the total cost. In today's environment of rapidly changing technology, the Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems considered this an unacceptable risk and took concerted action. In 1999, the Technology Roadmapping process was developed as a Sourcing Tool for driving Concurrent Engineering to lower total acquisition cost.

Technology Roadmapping is a shared vision and framework for cooperative technology efforts. As a market transformation tool, it helps accelerate the adoption of new technologies and mitigate risk. The mitigated risks include obsolescence, use of new technology, design upgrades, and supplier base instability. Roadmapping is accomplished by internal and external market research, Lockheed Martin supplier team building, and integrated supplier technology insertion. In this manner, supply base market dynamics are managed to ensure access to technology. For each technology area, an Integrated Product Team (IPT) — consisting of a sourcing engineer, buyer, supplier quality engineer, components engineer and design engineer with Manufacturing, Life Cycle Support, and Marketing representatives — is formed. Key aspects of supplier focus include re-negotiation based on cost understanding and leveraging of capabilities beyond the immediate objective.

As a consolidated purchasing organization, MAC-MAR serves as a technical link between business units. Sourcing comprehensively monitors buying and facili-

tates supplier relations among sites. With a well-defined leadership role, sourcing can coordinate process improvements, influence supplier technology roadmaps, establish special pricing agreements, perform risk assessments, and facilitate integrated product development. Process results include key technology capture, industry alignment, reduced research and development costs, design stability, and the establishment of a strategic supply base. MAC-MAR effectively tracks supplier part obsolescence and facilitates design for replacement. In one case, a specific Kaizen connector event reduced total cycle time from 28-to-113 days to 11-to-60 days. Actual process time was reduced from 44-to-60 hours to 38-to-50 hours. The connectors, semiconductors, and radio frequency technology areas have been completed by MAC-MAR. The cables, magnetic devices, and power supply technology areas are currently in progress.

Year in Review Booklet

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems published its first Year in Review booklet in 2000. Its purpose is to share the year's events, successes, and recognitions with employees and their families. The booklet is also shared with customers and is being used in the recruiting process.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems wanted a way to recognize the accomplishments of employees, encourage them to think like business owners, be engaged in the success of the business, and attract and retain talented personnel. The company also wanted to showcase its employees, events, and successes to the families of employees. In late 2000, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the first Year in Review booklet.

This professionally published booklet serves as a microcosm of the business year, highlighting employees, programs, accomplishments, milestones, contract awards, and technology areas within the company. The booklet is mailed to the home of every employee, so they may share it with their families. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems also provides copies for its customers, uses it as a recruiting tool, and posts an electronic version on its web site for further dissemination.

The booklet includes:

- Business - Looks at how the company outperformed traditional and new competitors, and met business challenges with commitment and innovation.
- Technology - Describes how technology is the lifeblood of the Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems family, and includes information on patents received and technologies which spurred the company's competitive posture.
- Partnerships - Shows how working with other businesses allows all to share, learn, and combine technological knowledge to provide the best value and product to the customer.
- A Winning Workplace - Documents the company's awards for environmental, safety, health, and security programs. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems also celebrates its employees through numerous business awards.
- People - Shows how the company has created a work environment that fosters creativity, job autonomy, and opportunities for career development as a major part of the business mix.
- Neighbors - Through its employees' sense of community and volunteerism, the company provides support to the communities where they live and work.
- Testimonials - A collection of quotes from employees who laud the company for the work environment it has created.

The Year in Review booklet strongly supports employee morale, recruiting efforts, customer relations, media relations, and community relations. Most importantly, it gives a personal touch to the business side of the company. The year 2000 held significant accomplishments for the Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems family, and this booklet has done well in documenting those successes. The 2001 Year in Review booklet is already on the drawing board, ready to raise the bar of success of the first edition.

Section 3

Information

Design

Action Item Database

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the Action Item Database, making it possible to assign and track action items in an efficient manner. This database, along with its overall process, eliminates misconceptions as to who is assigned actions and whether or not the actions are completed and approved.

Previously at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, a manual method existed for assigning and tracking action items. This antiquated approach involved memos and paper lists to maintain the tracking, often leading to duplicated efforts in the assigning and performance aspects of the actions. Multiple individuals, unknowingly, might be working on the same action item since items were often assigned multiple times under different names. To resolve this situation, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the Action Item Database, a formal open/closure procedure for handling action items.

The Action Item Database utilizes Microsoft Access to streamline the overall process; assign and track action items; and automatically send out e-mail notifications at each step. Any team member can identify an action item by recording it on an electronic form and e-mailing it to the Action Item Manager. The Manager reviews the item and submits the information to the Originating Integrated Product Team (IPT) Lead. This Lead can either disapprove or approve the action item. If the Originating IPT Lead disapproves the action item, the team member who initiated the item is notified as well as the Action Item Manager who logs the response into the Action Item Database. If the Originating IPT Lead approves the action item, the Action Item Manager is notified to log the item into the Action Item Database. Notifications are then automatically e-mailed to the Responsible Individual (RI) and the Responsible IPT Lead. After performing the action item, the RI fills out a response form which is e-mailed to the Originating IPT Lead, the Responsible IPT Lead, and the Action Item Manager. If all concur, the Originating IPT Lead approves the completion and notifies the Action Item Manager to close out the item. Weekly reports on action items are distributed and discussed at weekly IPT meetings.

The Action Item Database provides Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with a seamless procedure for assigning and tracking action items. This software structure, along with the overall process, streamlines the action items so personnel can concentrate on performing the assigned action and not concern themselves with the validity of the action item. IPT Leaders have a fast and easy way of checking on actions assigned and determining their status. Performance requirements are met by identifying and tracking potential problems and issues in the beginning stages, thereby saving time and money.

Contractor/Customer Integrated Product Teams

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established Contractor / Customer Integrated Product Teams for its product development programs. This approach fosters better communication with the customer during design and development, resulting in a more effective and efficient program.

In the past at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, product development was based on contractor understanding of customer requirements. Periodic customer design reviews were held to access the development process and recommended product. Customer concurrence was required in order to continue with the process. This approach created the possibility of redesign and rework based on the customer's response at the design reviews. As often was the case, this situation caused Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to spend additional time and money on redesign and rework because either the customer's requirements

were not fully understood or the customer did not understand the company's product and development process. To increase program efficiency and effectiveness, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems created Contractor/Customer Integrated Product Teams (IPTs).

This approach fosters customer involvement throughout the development cycle, and prevents lengthy work effort which does not meet the customer's needs. The customer attends all IPT meetings and participates in the development decisions. By establishing a line of communication between participants, issues and problems can immediately be resolved. The design reviews become fewer and more informal due to the customer's knowledge of the process and product through attendance at IPT meetings.

The Contractor/Customer IPTs minimize the possibility of redesign and rework because the customer is involved throughout the design process. This approach also results in real-time customer feedback; reduces the chances of misunderstandings; simplifies design reviews; and prevents multiple, if any, design review action items. The Contractor/Customer IPTs enable Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to develop an acceptable product within cost and schedule, thereby increasing customer satisfaction levels.

Engineering Change Notice Reduction Board

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed the Engineering Change Notice Reduction Board as a way of examining Engineering Change Notices to determine root causes and recommend corrective actions. The Board is comprised of designers, engineers, and upper level management.

To improve its overall design process, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems needed a way to provide better visibility into the causes of Engineering Change Notices (ECNs). In addition, no method existed to prevent ECNs from recurring. To address these issues, the company implemented the ECN Reduction Board (ERB).

The ERB is comprised of two digital design engineers, a mechanical engineer, a reports group representative, and two to three first-level managers. Meetings are held monthly, and typically two to three additional individuals at random are invited to observe the process. At these meetings, the Board evaluates and categorizes all digital hardware ECNs; performs root cause analysis on preventable ECNs; and identifies and incorporates process/tool/training corrective actions.

Engineers originating an ECN present the root cause and corrective action to the ERB. The Board can either approve or disapprove the corrective action. If the Board disagrees with the recommendation, the engineer is given an opportunity to defend the proposed corrective action. The Board review is repeated until all parties agree on the suggested corrective action. At that time, the ERB assigns individuals to map the processes and determine the costs associated with implementing the corrective action. At the next meeting, the responsible individuals present their reports to the Board which, in turn, adopts a corrective action. To prevent ECNs from recurring, a database tracking process is used.

Since implementing the ERB, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems realized a $1.7 million cost avoidance savings. Additional benefits include improved design practices and tools, and a reduction in ECNs, rework, and cycle time.

Risk Management Process

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed a Risk Management Process to measure the probability of adverse affects or risks. The process defines a strategy for dependable input and output requirements so that processes can be consistently applied.

In the past, risk tracking was an undisciplined, subjective process performed by various individuals. The company often underrated the consequences of risk reduction for its customers. In response, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed a Risk Management Process to measure the probability of adverse affects or risks.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems believes that risk identification is everyone's job, so risk evaluation is now performed through Integrated Product Teams (IPTs). The Risk Management Process involves Risk Identification; Risk Assessment and Analysis;

Risk Mitigation; and Risk Tracking and Control. Risk Identification involves uncovering new issues, tracking existing ones, performing quarterly evaluations across the work breakdown structure, and classifying issues into risk categories. Risk Assessment and Analysis involves identifying critical risk issues, qualifying potential program impacts, evaluating interdependencies, assigning probability and consequence of occurrence values, performing hardware/software proofing, and testing. Risk Mitigation involves developing plans for handling and tracking risk issues, evaluating cost/effectiveness, and documenting the plan. Risk Tracking and Control involves updating the databases on current knowledge of risk, developing a risk assessment report and management plan, disseminating the reports to the Team and customer, and holding a Risk Review Board meeting.

Understanding the structured and systematic procedures are essential to the early detection of risk in an engineering environment. Standardizing the Risk Management Process enables an IPT to determine the high-risk elements in need of risk mitigation, and make effective decisions based on risk evaluation and tracking. This cost-effective approach has the potential to unify efforts in risk management across IPTs and company disciplines.

Production

Plastic Chip on Flex Transmit/Receive Module Fabrication Process

The Plastic Chip on Flex Transmit / Receive Module Fabrication Process represents the next generation of the baseline ceramic process, and is used in shipset, commercial, and space applications. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems and other activities are investigating its uses in stress testing and reliability assessment.

In the late 1980s, the baseline ceramic process was invented by General Electric's Corporate Research and Development Center. A commitment for research funding with this Center was made as part of a 1992 agreement to General Electric in the General Electric-Aerospace Group sale to Martin Marietta (later Lockheed Martin). The Plastic Chip on Flex (PCOF) Transmit/Receive (T/R) Module Fabrication Process represents the next generation of the baseline ceramic process.

The PCOF T/R Module Fabrication Process uses low-cost, commercial-off-the-shelf (COTS) materials. The process also features quick turnaround prototyping (no long lead materials), and 3X weight and size advantages over equivalent chip and wire designs. The PCOF T/R Module Fabrication Process is used in shipset, commercial, and space applications.

As estimated by the Envision Cost Model, the PCOF T/R Module Fabrication Process produced a cost savings to the Navy of $7 to $10 million per shipset. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is currently testing this process for Navy use with Highly Accelerated Stress Testing. Reliability Assessment is also underway in cooperation with the Naval Surface Warfare Center, Crane Division; and the Computer-Aided Life-Cycle Engineering, Electronic Package Research Center.

Safety Support Team

The Safety Support Team operates as an additional communication link between the Environmental, Safety, and Health Committee and the Operations Work Centers. The Team also provides employees with a focal point that can address their environmental, safety, or health concerns.

Participation in OSHA's Voluntary Protection Program required a company to continuously improve its process for involving employees in health and safety. Although the Environmental, Safety, and Health (ESH) Committee at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has been in place since 1995, not every Operations Work Center was represented on the committee. As a way to get its employees more involved with the Committee, the company established the Safety Support Team in January 2001.

The Safety Support Team is comprised of members from all work centers, and operates as an additional communication link between the ESH Committee and the Operations Work Centers. The Team also provides employees with a focal point that can address their environmental, safety, or health concerns. Meetings are held every two weeks. Attendance is good, and employees have been very vocal in bringing up environmental, health, and safety issues. During the meetings, the Team also previews safety videos and maintains a database of issues. Members wear badges to indicate they are

part of the Safety Support Team. Safety handouts and posters are placed around the company to enlighten employees and familiarize them with the team members.

Since being established, the Safety Support Team has received 48 ideas and concerns from all the Operations Work Centers at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. Of those submitted, 34 have been closed. The Safety Support Team is an excellent morale builder which establishes an effective means of communication between the ESH Committee and the Operations Work Centers.

Solid Waste Recycling Program

In 1997, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established its award-winning Solid Waste Recycling Program. Employee cooperation, dedication, and education provided the thrust to rejuvenate the company's recycling initiatives.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems had implemented a white paper recycling program in 1996. Due to limited market opportunities, the company still landfilled other items such as colored papers, newsprint, magazines, books, and cardboard on a daily basis. A proactive approach to landfill avoidance identified a recycling broker who accepted all paper types mixed in one collection container. In 1997, the company implemented its award-winning Solid Waste Recycling Program.

All departments at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems participate in the Solid Waste Recycling Program. Collected materials are sorted for recycling by the recycling broker for a contracted fee. The company also recycles plastics, wood, metals, obsolete computers, toner cartridges, and viewgraphs. On a seasonal basis, local packaging businesses utilize some of the company's excess packaging materials. Environmental awareness education is provided to employees in support of this renewed recycling initiative, thereby promoting participation. Labels on all recycling collection bins specify current recycling guidelines. Wall posters and other reminders placed around the facility encourage employees to print two-sided copies and to utilize electronic communications whenever possible.

Since implementing the Solid Waste Recycling Program, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems realizes better than a 50% recycling rate while advancing employee conservation of natural resources throughout the workforce. Increased recycling rates can be attributed to employees' strong commitment to the company's ISO-14000 Environmental Management System. The Solid Waste Recycling Program helps reduce landfill costs, enhances the company's public image, and promotes employee pride. In 2000, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems was one of only two large businesses to receive the Commissioner's Recycling Award presented by the New Jersey Department of Environmental Protection.

Logistics

Logistic Support Analysis/Integrated Logistics Support Database

The Lifetime Support Operations at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented a Logistic Support Analysis / Integrated Logistics Support Database. This system successfully manages reliability, maintainability, and availability of information in a standardized, user-friendly format.

Historically, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems produced independent Logistic Support Analysis (LSA)/Integrated Logistics Support (ILS) products for each system. Data was collected, reported, and presented in various formats. A standardized, centrally supported application to capture, store, and manage data did not exist. In February 2001, the Lifetime Support Operations at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented a universal LSA/ILS Database for data collection, storage, and report generation.

The LSA/ILS Database was created in Microsoft Access and can integrate with the Microsoft Office suite of products. As a flexible tool for ongoing development, this network-supported database is structured to support reliability assessment as well as comprehensive maintenance activities. The LSA/ILS Database products include Failure Modes Effects and Criticality Analysis (FMECA) summaries, maintenance significant item reports, maintenance task summaries, task analysis summaries, and test

equipment lists. Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) are tracked for each catalogued item. Maintenance Task Analyses are performed using FMECA outcomes, thereby expanding repair information for improved item availability. End effects of all failures are rolled up to the system level, providing both microscopic and macroscopic availability perspectives. Due to the criticality of certain functions (e.g., reliability assessment), the LSA/ILS Database is password protected by category to inhibit cross-migration of data. The system also maintains item locations and stores preventive maintenance procedures. Test equipment maintenance/calibration and item measurement range variations (e.g., graceful degradation) are handled as well.

The LSA/ILS Database is customized to the Statement of Work, performs at the organizational level, and supports several programs simultaneously. The database enabled Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to standardize, streamline, and reduce the overall cost of developing, implementing, and managing an integrated logistics program.

Management

Aegis Depot Operations Synergy with Manufacturing Operations

The Aegis Depot Operations uses a synergistic approach with the Manufacturing Operations to increase its capacity in meeting growing demands and peak workloads. Resource sharing allows both operations to benefit without hiring additional personnel or compromising business practices.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is the prime contractor for manufacturing and integration of the Aegis Weapons System (AWS) and Aegis Depot Operations (ADO) for the Navy. ADO was a standalone activity with the capacity to perform Supply Support for NAVSEA, during the Interim Support phase of the Shipbuilding Process and Supply Support for NAVICP and the Aegis Fleet. As the customer's concept of how to best perform Supply Support changed, ADO's workload increased. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems was driven by the desire to compete as the prime vendor for Supply Support; however, its capacity was being challenged especially in times of peak demands. The obvious solution was to expand the capabilities and scope of ADO, but the company preferred to do this in a cost-effective manner.

Originally, ADO consisted of three entities: Requirements Group, Material Control Group, and Repair Facility Group. Each entity relied on various Manufacturing Operations activities for support. To address the issue of increasing depot capacity, both ADO and the Manufacturing Operations identified similar capabilities and operational differences which could be shared. Primary candidates for shared resources (or synergy) included test, repair, inspection, packing, and stockroom personnel. Operational differences were addressed to bring resources in line with ADO without compromising the Manufacturing Operations. Additionally, extensive planning was undertaken to provide accurate workload forecasts, train personnel to be flexible, and provide timely workload scheduling to optimize the synergy between the two operations.

Prior to the synergistic approach, ADO's capabilities were limited in capacity by the number of available labor support hours of assigned personnel. After implementing the approach, the capacity grew because ADO could access additional personnel from the Manufacturing Operations. Synergy allowed ADO to meet the needs of a growing business and satisfy peak demands. ADO is now positioned to compete as a prime contractor for Supply Support to the Navy, as well as take on other projects.

Cable Database

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established a Cable Database to provide real-time information on cable parts and configurations. Key to its success was the customized use of Lean and Six Sigma improvement processes.

In the past, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems used a manual method of design review to identify possible matches between old and new baseline designs. This method was very labor intensive and not very accurate, considering that thousands of cables had to be reviewed in each drawing. To resolve this dilemma, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established the Cable Database.

The company created the Cable Database by employing a unique blend of Lean and Six Sigma improvement processes. The Lean and Six Sigma

methodology was customized to work on a process involving 27 key subject matter experts (SMEs) in a manner that significantly shortened the process redesign time to meet the urgent business need. The entire redesign and implementation were accomplished in one month. The Cable Database provides a method of locating resident cables in the Product Test Center and re-using them to test future design versions. By creating a database compatible with the design software, all new design cables can now be compared to existing cables. This approach locates matched cables in minutes rather than months. This Access-based tool can sort by component attributes, and can be applied to other sites in Moorestown as well as across the Lockheed Martin Corporation.

Since implementing the Cable Database, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has reduced cycle times and produced significant savings. The cost savings from both re-used cables and labor are estimated at $1 million for one new design version. The savings for labor alone are conservatively estimated at 0.2 hours per cable for 1,300 cables.

Government Property Management System

The Government Property Management System uses continuous process improvement along with the identification and adoption of best practices to manage government-owned property. The current focus on improvement of this activity is on strengthening the infrastructure of continuous process improvement.

During the course of operation, contractors acquire a large amount of government-owned property. To comply with contractual/regulatory requirements as well as efficiently implement best practices, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Government Property Management System. This system uses an established infrastructure of continuous process improvement along with the identification and adoption of best practices. To identify, create, and propagate best practices, this infrastructure employs policy and management support; personnel; control systems; and external associations. Additional drivers of the process are the use of Lean and Six Sigma trained personnel, and participation in government process teams.

The company's corporate and site property management policy provides authority and responsibility to the Site Property Manager, as required, to assure policy compliance. Policy is carried out through the Corporate Property Council which provides a channel for participation and buy-in from the different stakeholders in the process. As opportunities for improvement are identified, this Council has the responsibility to establish, identify, and promulgate best practices. The Government Property Management System utilizes various control systems including appropriation process, a web-based property management database, a corporate redeployment database, a web-based self-audit system, the Corporate Property Council's semi-annual best practices surveys, and web-based procedures. The National Property Management Association provides training resources and the Aerospace Industries Association promotes regulatory reform. Additional personnel involved in the process are Property Custodians, Site Property Council, Site Property Management/Contracts, Corporate Property Council, and Corporate Vice President of Contracts.

By continuously improving its property management infrastructure, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems assures efficient property management at a reasonable cost. The company maintains its designation as a responsible supplier to the government, which creates repeat business and growing capabilities to meet government needs. Since 1995, the Government Property Management System has been recognized as a Lockheed Martin 21 best practice. Consistent with the company's continuous improvement policies, the adoption and creation of additional practices are driven by emerging regulations and efficiency requirements of the business world. The current focus on improvement of this activity is on strengthening the infrastructure of continuous process improvement.

KeyComm Meetings

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems established KeyComm Meetings as a communications tool between the Senior Leadership Team and employees. These monthly meetings are used to address employees' questions and concerns as well as discuss current business issues and initiatives.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems instituted KeyComm Meetings as a communications process to facilitate a top-down flow of information from the Senior Leadership Team (SLT) to the employees. This interactive process provides the opportunity for employees to ask questions of senior management regarding business issues and their affect on employees; and for management officials to address these questions in real time.

The KeyComm Meetings are monthly hour-long sessions between the SLT and employees. Prior to the meeting, the SLT establishes an agenda and publishes it on the KeyComm web site. The agenda helps prepare and inform the audience on the subjects to be discussed. Questions are solicited from employees prior to the meeting to encourage participation and interactions. These questions are forwarded to the SLT via the Intranet or other means. At the meeting, formal presentations scheduled on the agenda are conducted first. Employee questions are then answered during the meeting and/or posted on the KeyComm web site. The meeting is held in a large 250-person seating capability auditorium with a dual screen projection system. Since all employees are invited to attend and seating room is limited, those in attendance normally flow down the information to their groups in staff meetings, round tables, and general meetings within their work groups. In addition, non-proprietary presentations are posted on the KeyComm web site in PowerPoint, PDF, and print-friendly black and white versions to facilitate distribution of the information.

By implementing KeyComm Meetings, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems keeps its employees abreast of business news and facilitates a sense of ownership within the company. Senior management and employees now have a venue that encourages two-way communication of issues and concerns. An added benefit is that employees no longer feel they must rely on grapevine rumors to learn what is going on with the business. This communications tool reduces the propagation of false information. Future plans call for this tool to be spread to remote sites of the company through the use of new broadcast encoding technology. This improvement will allow even more employees to participate in the meetings on a real-time basis.

Managing a Secure Area

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems revised its security process to protect all classified material at its facility. A key issue of the process is ensuring that secure data is not compromised nor creates interference with program operations.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' security process has been an evolution of practices to limit security violations; ensure proper identification of program materials; identify a common repository for program materials; increase security-related communications; and improve overall security knowledge of the workforce within a classified environment. A key issue of the process is ensuring that secure data is not compromised nor creates interference with program operations.

Past issues have been rectified by the company through the implementation of new endeavors. Co-located Information System Security Officers (ISSOs) are now assigned to all program teams and closed areas. These individuals, depending on the breadth of the program area, spend 10% to 50% of their time working security matters. The remainder of their time is devoted to working a particular portion of the program. Other endeavors of the security process include random self-audits by ISSOs; annual security audits by Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems; maintenance practices to keep employees up-to-date on the latest security issues, requirements, and procedures; and monthly meetings and question/answer sessions to highlight best practices, changes, and issues.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' revised security process maintains compliance with program security requirements to ensure that secure data is not compromised nor creates interference with program operations. The integration of network and security personnel with the program team offers easy access for timely issue resolution and administrative support. In May 2001, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems received an overall security rating of excellent from a Defense Security Service audit.

Material Request Process

In 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems revised its Material Request Process. As a result, the company resolved material analysis problems that had resulted in a $3.5 million misclassification of direct materials and related inappropriate burdens.

Previously at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, material requests were used to order non-production direct and indirect materials. Approximately 300 employees were eligible to issue material requests; however, no formal training or packaged guidelines existed for these Material Request Analysts. The result was continuous monitoring and journal entry adjustments, and a significant misclassification of direct materials and related inappropriate burdens. In 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented a revised Material Request Process that consolidated the 300 Material Request Analyst positions into 18 positions.

The 18 Material Request Analysts serve functional disciplines across the entire business. Site Material Requesters use on-line forms to document material request data. These forms are sent electronically to the Material Request Analysts who process them into the corporate Consolidated Purchasing System. The Analysts track the ordered material from the time they are logged into the system through to the approval cycle. Tracking provides visibility to the Finance/Manager through the Sourcing Buyer's queue. Each week, the Material Request Analysts e-mail status reports to the related requesters. The Material Request Process also includes a responsibility matrix for both Analysts and Approvers. The procedure, a Material Request Approver listing, and training documents are now accessible through the company's web site.

Since implementing the Material Request Process, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems resolved material analysis problems that had resulted in a $3.5 million misclassification of direct materials, internal audit oversight, and related inappropriate burdens. The process also enables the company to efficiently monitor and train its Material Request Analysts. A cost auditing monitoring process revealed that direct material misclassification has been significantly abated, and metrics exist to alleviate engineers' fears that their processes would be delayed by strict adherence to the Material Request Process.

Program Management Office Web-Shared Data

The Program Management Office Web-Shared Data initiative provides an automated process to better support the communication needs among Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems project / team members, Internal Program Office personnel, and Navy customers. The expanded, robust web site consolidates program information into one easily accessible source.

In 1997, the Production Program Management Office (PMO) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems expanded its web site into a resource for communicating program information to Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems project/team members and Navy customers. Internally, the web site provides the PMO team with an efficient way to access information on the Internet. The design and development strategy was to link existing PMO-related sites (internal and external) into an organized structure, and promote its use across Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems projects/teams.

In support of corporate's paperless communications effort, the web site provides a consolidated source for consistent communications. Up-to-date information is readily available to the user community. The web site places the PMO Home as the hub to six categories of information: news, events, customers, references, activities, and employees. Web traffic reports generate important insights, such as identifying areas of interest across the company, which are used in the continuous development of knowledge management capabilities.

The PMO Web-Shared Data initiative provides an automated process to better support the communication needs among Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems project/team members, Internal Program Office personnel, and Navy customers. The consolidation of program information into one source also contributes to a paperless communications effort by increasing the ease of access to current information. Since implementing the Web-Shared Data initiative, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems realized a growth in

web activity (on average) from 1,500 hits per month in 1999 to 8,979 hits per month. The average number of users per month also increased from 120 in 1999 to 326 in mid-2001. The company expects these rates to rise as the web site is expanded and becomes more robust.

Quality, Ethics, and Mission Success Organizations

The Quality, Ethics & Mission Success Organization embraces the philosophy of doing what is right all the time, and continuously focusing on improvement. The focus on principles such as honesty, integrity, responsibility, trust, respect, and citizenship has enabled Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems to establish a foundation for employee pride and job satisfaction.

Quality, ethics, and mission success are elements that embrace the philosophy of doing what is right all the time, and continuously focusing on improvement. Previously at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, these elements were addressed by two separate organizations: Quality and Mission Success which reported to the president of the company; and the Ethics Office which reported through the Finance Department to the president. In 1999, an analysis of synergies and organizational objectives combined the two groups into the Quality, Ethics & Mission Success (QE&MS) Organization.

The QE&MS Organization provides facilitation and leadership to apply quality, ethics, and mission success throughout the company, and achieve vision, mission, and customer satisfaction. Annual ethics refresher training allows employees to practice their skills for recognizing unethical behavior; familiarize themselves with case studies; identify judgment errors; and discuss proper behavior. A feature tool of the ethics training is a humorous video. The QE&MS Organization also provides for the improvement of business processes and systems through the application of Lean and Six Sigma methodologies. Open communication is always welcome, and employees are encouraged to raise issues/concerns and make suggestions for improvement.

The QE&MS Organization strives to promote an ethical environment. As a result of these efforts, employees report they feel more satisfied with their job, company, and ethics training; more comfortable with the company's response to reports of misconduct; have less fear of reprisal; and believe the company's commitment to ethics has increased. This organizational approach provides the required skill sets to facilitate improvement activities, and gives employees an avenue to suggest improvements and raise issues. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is embracing this approach at its other business sites.

Small Business Program

The Material Acquisition Center Mid-Atlantic Region at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems integrates its Small Business Program through all of its business processes. This program has repeatedly demonstrated its ability to meet and even exceed government-mandated goals.

The Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems actively maintains an outstanding Small Business Program to comply with government-mandated public law requirements. The group promotes numerous subcontracting, good faith, and mentoring opportunities for small; disadvantaged; minority-owned; women-owned; veteran-owned; and historically underutilized business zones (HubZone) businesses.

Headed by the corporate procurement office, Small Business Councils exist in the Aeronautical Systems, Technology Systems, Spare Systems, and MAC-MAR's Systems Integration organizations. Sound measuring and reporting mechanisms are in place. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems' program advocates and assists small business growth. The company works with these businesses in conjunction with specific programs to increase their capabilities in a particular area, enabling them to operate more competitively and independently. Strong outreach efforts include trade shows, database and web site searches, and an internal sharing of information within Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems itself.

MAC-MAR integrates the Small Business Program through all of its business processes. The group utilizes exceptional buyers' awards programs such as:

- Instant Recognition, which provides a lunch check for the cafeteria.
- Good News Award, which provides quarterly peer recognition of employees who do outstanding work.
- The 250K Club, which awards $250 to employees that place a minimum of $250,000 with a small disadvantaged business.
- The Millionaires Club, which awards a maximum of $1,000 to employees that place a minimum of $1 million with a small disadvantaged business.

Supplier Process Surveillance

In 1999, the Material Acquisition Center Mid-Atlantic Region at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Supplier Process Surveillance. This program focuses on process controls to ensure quality materials, and serves as a team-oriented vehicle for handling product anomalies.

Previously, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems used traditional supplier product acceptance methods which relied on costly inspections upon receipt or conducted at the supplier's location. Despite large numbers of dedicated inspection personnel, the company could not fully protect its assembly operations from process-related product anomalies. In 1999, the Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Supplier Process Surveillance (SPS) which shifted the emphasis of quality from inspections to process controls.

Supplier eligibility for the program is an active status with open purchase orders, and sufficient part quantities and work in processes (WIPs). The first step of SPS is the creation of a Technical Data Package (TDP), which is a team effort by the technical specialist, technical engineer, and supplier. TDP is used to baseline the supplier and takes about two months to complete. As a minimum, the Package contains a process map, a surveillance plan, critical process identification, process indicator points (if applicable), and a surveillance schedule which is a table of process checklists. Minimum requirements are determined by supplier category (e.g., manufacturer and distributor; manufacturer only; distributor; and manufacturer of custom parts). Reviews are predetermined by the TDP team.

The technical specialist performs the checklists according to schedule. Review results are then forwarded to the technical engineer and maintained in the Supplier Quality System. If anomalies are found, corrective action is requested and the supplier's quality rating is affected. The technical specialist communicates with various parties and visits the suppliers as necessary. After a three-month period, suppliers with good quality ratings may be evaluated for MAC-MAR's Dock-to-Stock Program. Once approved, this qualification eliminates incoming inspections and shifts the burden to supplier process controls. Evaluation criteria include quality rating, corrective action status, trend analysis, critical process assessment, and an approved quality system. A Risk Review Board meeting is held to review supplier nominations. The Board consists of a Defense Contractor Management Agency representative, supplier quality management, a technical engineer, and an SPS administrator. During these meetings, the Board can vote suppliers into a Dock-to-Stock status.

SPS promotes predictable quality performance and efficient supplier oversight, thereby developing supplier process improvement and securing a high performance supplier base. Currently, 100 suppliers are in the program. Of these, 28% have achieved a Dock-to-Stock status. The program's objective is 50%.

Supply Chain Management Command Center

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is implementing a centralized data and management supply chain center with enormous promise. The Supply Chain Management Command Center will utilize sophisticated demand planning tools and forecasting systems.

Historically at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, supply chain management has been a manual, decentralized process using home-grown legacy systems. These legacy systems, however, did not interface with the systems of trading partners or transportation. In addition, the company's commercial supply chain management software and demand forecast-

ing tools were not designed for use by non-mathematician inventory planners. Currently, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems is implementing a centralized data and management supply chain center with enormous promise.

The goal is to have a web-based system and call center that can look at daily inventories and transportation schedules. Based on the sound inventory control philosophies of NAVICP in Philadelphia and Mechanicsburg, Pennsylvania, the Supply Chain Management Command Center will enable the Navy to focus on managing suppliers and not just supplies. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems has made a large investment in a commercial transaction and planning system. The state-of-the-art logistics command center will serve as the focal point for all logistics and/or supply chain information.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems recently won a contract to manage all naval aircraft tires using its Supply Chain Management Command Center. Early results have demonstrated the ability of the company to address a real need within the supply community. Future success may result in Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems becoming the inventory manager, as well as the systems integrator, for the Aegis programs.

Supportability Engineering Analysis Report

The Supportability Engineering Analysis Report is an in-house electronic manual. This manual helps identify items of supportability concern and ways to mitigate them.

Although its Integrated Logistic Support Plan was designed for ships and systems, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems attempted to use this process for individual equipment. Supportability documents were implemented; however, they were not kept at a single location. Initially, all equipment systems were designed by Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems but, subsequently, commercial-off-the-shelf (COTS) equipment began being added piecemeal through engineering change proposals. To provide centralized maintainability and supportability aspects in a user-friendly environment, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems developed and implemented the Supportability Engineering Analysis Report (SEAR).

SEAR is an in-house electronic manual. This manual provides information on determining the optimum maintainability support strategy for equipment, and enables the company to maintain a balance among all supportability and maintainability criteria reflected by readiness, operational capability, life cycle cost, and Integrated Logistics Support. SEAR addresses supply support, life cycle cost, Combat Systems Operational Sequence Systems, preventive/corrective maintenance plans, support equipment, technology refresh/insertion plans, configuration management, Fleet support, hazardous materials, human engineering, technical manuals, and training. In addition, this manual documents the results of Maintainability/Supportability Engineering Analysis by addressing Failure Modes Effects and Criticality Analysis, reliability centered maintenance, level of repair analysis, and maintenance task analysis. SEAR is required to ensure that design-drive ownership costs are minimized for the life of the program.

Through SEAR, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems can identify items of supportability concern and ways to mitigate them, and assist customers in planning future budgetary requirements by defining total ownership cost and developing a technology refresh/insertion plan. Funded by PMS400 (Aegis) and Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems for four different systems, SEAR has proved to be very cost effective. The ultimate goal is to implement this method on-board all ships, so that the manual will be electronically available to sailors.

Technical Operations Program Review

In 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Technical Operations Program Review. The Review provides a condensed, standardized review of all aspects of program status for the vice president of Technical Operations, and fosters metric utilization.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems originally used three separate engineering groups to gather program-related data and assess engineering performance across its business. However, no standardized pro-

cess existed across the three groups. In addition, the vice president of Technical Operations faced the challenge of managing a matrix organization. Personnel and resources were allocated from the parent functional group to a specific project, for the duration of that project, before being made available to another project. This approach increased the difficulty of maintaining detailed situational awareness by the vice president and senior staff. In 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems combined the three groups into the Technical Operations and implemented the Technical Operations Program Review (TOPR).

TOPR provides a condensed, standardized review of all aspects of program status. Financial, schedule, technical, staffing, cost estimate, business opportunity, and engineering status data are gathered and contrasted against top-level program assessment criteria across the entire Technical Operations organization. This information is then organized by project and sub-project. In support of TOPR, finance and engineering staff work together to summarize financial performance on all program tiers. Actions items are an important part of the standardized data process. These items are recorded and tracked with an on-line, company-wide database.

Monthly four-hour meetings are held to review the synthesized information by the vice president of Technical Operations, the senior staff, and responsible project personnel. The great volume of information is displayed in summary boxes based on risk status (green for low, yellow for medium, red for high). Here too, action items are reviewed and updated. If deemed necessary, management can determine the underlying components of the data via Microsoft Office software.

By using TOPR, Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems can obtain key status information from a concise review within four hours. The review covers approximately 380 status elements and 1,700 personnel. The Review also provides two-way communication between senior management and the Technical Operations, and standardizes the process for gathering program-related data and assessing engineering performance. In addition, TOPR meetings allow senior management and project personnel to interact so decisions can be made on reallocating resources and resolving roadblocks.

Thru-life Product Assessment Process

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Thru-life Product Assessment Process as an alternative analysis tool that can be used with any hardware selection. Customer buy-in has demonstrated great success, as program managers and Integrated Process Teams use this process to obtain better decision-making data.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems recognized the need for a generic selection model that would provide its program managers and Integrated Process Teams with better decision-making data. The result was the Thru-life Product Assessment Process (TPAP), a recently implemented alternative analysis tool which is tailorable to any hardware selection.

TPAP only collects and evaluates enough data to discriminate among hardware alternatives, prioritize them, and make a recommendation. Because the process is used as a procurement selection evaluation tool, it is mandatory that the questions and scoring be formalized and well documented *before* the selection begins. A template asks a series of questions, then ranks and rates nine categories (technical performance requirements, technical documentation, configuration management, reliability and maintainability, program management, training, sourcing, supportability, total ownership cost) with a numerical response. Based on pre-determined criteria, the scores are tallied and presented either numerically or graphically. Subcategories and questions are then added under each category. The data collected also feeds downstream activities.

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems initially developed TPAP as an Aegis program-based system; however, the process is flexible enough to be adapted to future programs. This objective, repeatable process can be audited and provides qualitative results. Customer buy-in has demonstrated great success. Among the customers using this process are the Baseline 6 Phase IIIC, the Baseline 7 Phase I, the Integrated Deepwater System, and the Duran-Ballen 21 Blue Team.

Transition to Production Process

Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems implemented the Transition to Production Process as a derivative of its Eight-Step Process Improvement Program. This process is applied to new suppliers prior to purchase order award, and prevents various issues from surfacing later in a program.

In the past at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, the initial phases of production traditionally relied only on Production Readiness Reviews (PRRs) and qualifications to assure successful start-up. The most vulnerable circumstances were suppliers restarting production after prolonged inactivity, and new production start-ups of build-to-print items. Plans were typically presented in limited scope, yet still passed review. No risk mitigation plan existed. Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems resolved these issues by implementing the Transition to Production Process (TPP).

TPP is primarily a risk mitigation approach used prior to a supplier achieving "at-rate." At-rate is defined as the achievement of deliverable quantities as defined in the purchase order and to the purchase order specified schedules. The process is applied to first-run productions, changes in approved source of supplies, and production start-up after periods of inactivity. In addition, TPP assures handoffs of lessons learned during PRRs, qualifications, and other product and development activities.

TPP evolved from the Eight-Step Process Improvement Program employed by the Material Acquisition Center Mid-Atlantic Region (MAC-MAR) at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems. This process is less resource-intensive than its parent program, and is applied to the newest suppliers. To implement the process requires a detailed review of procurement documentation, verification of qualification requirements, a review of baseline processes and proposed manufacturing control flow plans, identification of key process points to determine risk areas, survey special processes, and a review of technology transfer needs. Additional steps may be added as necessary, especially when dealing with foreign suppliers. Issues identified by TPP are assigned to a site engineer for action, and status of activity is tracked through completion.

Through its review process, TPP prevents various issues from surfacing later in a program. Those that do present themselves are monitored by MAC-MAR to determine purchase order release decisions. The process also provides Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems with a venue for initiating a relationship with new suppliers.

Appendix A

Table of Acronyms

ACRONYM	DEFINITION
ACTFAST	Aegis COTS Technology Family Analysis and Selection Tool
ADO	Aegis Depot Operations
API	Application Program Interface
ASRB	Aegis Standard Review Board
AWS	Aegis Weapons System
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CCA	Circuit Card Assembly
CEE	Collaborative Engineering Environment
CEP	Continuing Education Program
COBRA	Counter Battery Radar
COTS	Commercial-off-the-Shelf
CPS	Computer Program Standard
CRAD	Contract Research and Development
DMS	Diminishing Manufacturing Sources
DSP	Digital Signal Processor
ECME	Electronic Contract Management Environment
ECN	Engineering Change Notice
EMI	Electromagnetic Interference
ERB	ECN Reduction Board
ERT	Emergency Response Team
ESH	Environmental, Safety, and Health
FEA	Finite Element Analysis
FMECA	Failure Modes Effects and Criticality Analysis
HAZMAT	Hazardous Material
HDI	High Density Interconnect
HHW	Household Hazardous Waste
IDE	Integrated Digital Environment
IETM	Interactive Electronic Technical Manual
ILS	Integrated Logistics Support
IPT	Integrated Product Team
IRAD	Internal Research and Development
ISSO	Information System Security Officer
IT	Information Technology
LSA	Logistic Support Analysis
MAC-MAR	Material Acquisition Center Mid-Atlantic Region
MAP	Manpower Analysis Process
MBB	Master Black Belt
MEC	Micro Electronic Circuit

MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NSCC	Naval Systems Computing Center
PCB	Printed Circuit Board
PCOF	Plastic Chip on Flex
PMO	Program Management Office
PPR	Production Readiness Review
PROCAS	Process Oriented Contract Administrative Service
PSMD	Preliminary Ship Manpower Document
PWB	Printed Wiring Board
QE&MS	Quality, Ethics & Mission Success
RFP	Request For Proposal
RI	Responsible Individual
SEAR	Supportability Engineering Analysis Report
SLT	Senior Leadership Team
SME	Subject Matter Expert
SPS	Supplier Process Surveillance
T/R	Transmit/Receive
TCM	Total Crew Model
TDP	Technical Data Package
TOPR	Technical Operations Program Review
TPAP	Thru-life Product Assessment Process
TTP	Transition to Production Process
WIP	Work In Process
WQ&SB	Watch Quarter & Station Bill

Appendix B

BMP Survey Team

Team Member	Activity	Function
Larry Robertson (812) 854-5336	**Crane Division** Naval Surface Warfare Center Crane, IN	**Team Chairman**
Cheri Spencer (301) 403-8100	**BMP Center of Excellence** College Park, MD	**Technical Writer**
	Design Team	
Ron Cox (301) 403-8100	**Naval Surface Warfare Center** Crane Division Crane, IN	**Team Leader**
Rob Marmo (570) 895-6690	**Tobyhanna Army Depot** Tobyhanna, PA	
Roberto Camino (909) 273-4004	**Naval Surface Warfare Center** Corona Division Corona, CA	
Nancy Russell (301) 227-1098	**Naval Surface Warfare Center** Carderock Division West Bethesda, MD	
	Production Team	
Robert Jenkins (202) 781-3743	**Naval Sea Systems Command** Washington, DC	**Team Leader**
Darrel Brothersen (319) 295-3768	**Rockwell Collins, Inc.** Cedar Rapids, IA	
Todd Brandt (909) 273-5552	**Naval Surface Warfare Center** Corona Division Corona, CA	

Management Team #1

Don Hill (317) 849-3202	**BMP Field Office** Indianapolis, IN	**Team Leader**
John Olewnik (215) 697-9526	**Office of Naval Research** Research Manufacturing Technology Detachment Philadelphia, PA	
Georgeann Wilcoxson (301) 403-8100	**BMP Center of Excellence** College Park, MD	

Management Team #2

Larry Halbig (317) 891-9901	**BMP Field Office** Indianapolis, IN	**Team Leader**
Joan Kraft (703) 751-1886	**Consultant** Alexandria, VA	
Rick Avery (909) 273-4995	**Naval Surface Warfare Center** Corona Division Corona, CA	

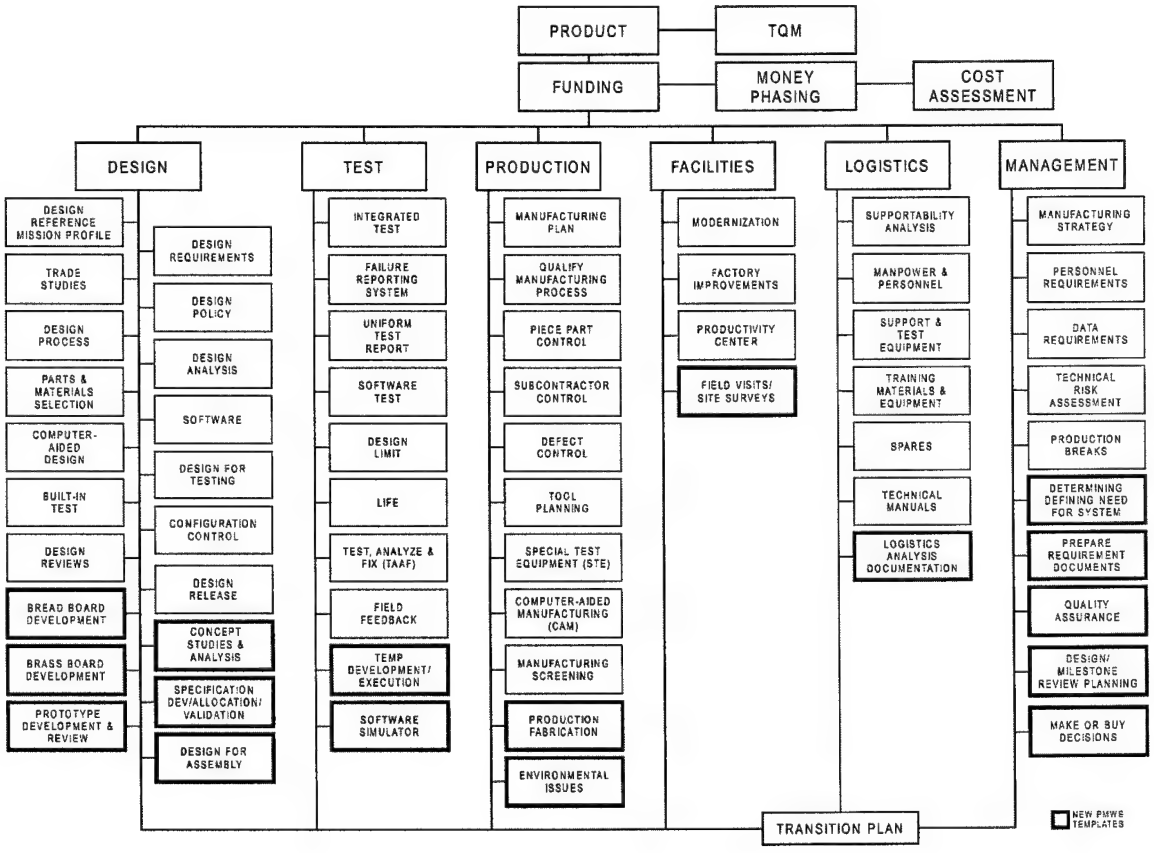
Appendix C

Critical Path Templates and BMP Templates

This survey was structured around and concentrated on the functional areas of design, test, production, facilities, logistics, and management as presented in the Department of Defense 4245.7-M, *Transition from Development to Production* document. This publication defines the proper tools—or templates—that constitute the critical path for a successful material acquisition program. It describes techniques for improving the acquisition process by addressing it as an *industrial* process that focuses on the product's design, test, and production phases which are interrelated and interdependent disciplines.

The BMP program has continued to build on this knowledge base by developing 17 new templates that complement the existing DOD 4245.7-M templates. These BMP templates address new or emerging technologies and processes.

"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"

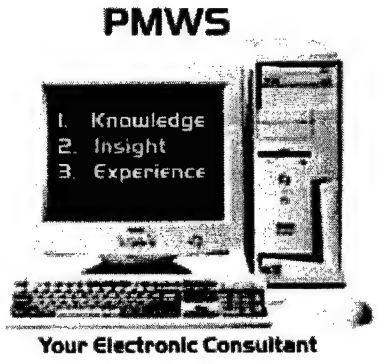


Appendix D

The Program Manager's WorkStation

The Program Manager's WorkStation (**PMWS**) is an electronic suite of tools designed to provide timely acquisition and engineering information to the user. The main components of PMWS are KnowHow; the Technical Risk Identification and Mitigation System (TRIMS); and the BMP Database. These tools complement one another and provide users with the *knowledge*, *insight*, and *experience* to make informed decisions through all phases of product development, production, and beyond.

KnowHow provides knowledge as an electronic library of technical reference handbooks, guidelines, and acquisition publications which covers a variety of engineering topics including the DOD 5000 series. The electronic collection consists of expert systems and simple digital books. In expert systems, KnowHow prompts the user to answer a series of questions to determine where the user is within a program's development. Recommendations are provided based on the book being used. In simple digital books, KnowHow leads the user through the process via an electronic table of contents to determine which books in the library will be the most helpful. The program also features a fuzzy logic text search capability so users can locate specific information by typing in keywords. KnowHow can reduce document search times by up to 95%.



TRIMS provides insight as a knowledge based tool that manages technical risk rather than cost and schedule. Cost and schedule overruns are downstream indicators of technical problems. Programs generally have had process problems long before the technical problem is identified. To avoid this progression, TRIMS operates as a process-oriented tool based on a solid Systems Engineering approach. Process analysis and monitoring provide the earliest possible indication of potential problems. Early identification provides the time necessary to apply corrective actions, thereby preventing problems and mitigating their impact. TRIMS is extremely user-friendly and tailorable. This tool identifies areas of risk; tracks program goals and responsibilities; and can generate a variety of reports to meet the user's needs.

The **BMP Database** provides experience as a unique, one-of-a-kind resource. This database contains more than 2,500 best practices that have been verified and documented by an independent team of experts during BMP surveys. BMP publishes its findings in survey reports and provides the user with basic background, process descriptions, metrics and lessons learned, and a Point of Contact for further information. The BMP Database features a searching capability so users can locate specific topics by typing in keywords. Users can either view the results on screen or print them as individual abstracts, a single report, or a series of reports. The database can also be downloaded, run on-line, or purchased on CD-ROM from the BMP Center of Excellence. The BMP Database continues to grow as new surveys are completed. Additionally, the database is reviewed every other year by a BMP core team of experts to ensure the information remains current.

For additional information on PMWS, please contact the Help Desk at (301) 403-8179, or visit the BMP web site at http://www.bmpcoe.org.

Appendix E

Best Manufacturing Practices Satellite Centers

There are currently ten Best Manufacturing Practices (BMP) satellite centers that provide representation for and awareness of the BMP Program to regional industry, government and academic institutions. The centers also promote the use of BMP with regional Manufacturing Technology Centers. Regional manufacturers can take advantage of the BMP satellite centers to help resolve problems, as the centers host informative, one-day regional workshops that focus on specific technical issues.

Center representatives also conduct BMP lectures at regional colleges and universities; maintain lists of experts who are potential survey team members; provide team member training; and train regional personnel in the use of BMP resources.

The ten BMP satellite centers include:

California

Chris Matzke
BMP Satellite Center Manager
Naval Surface Warfare Center, Corona Division
Code QA-21, P.O. Box 5000
Corona, CA 92878-5000
(909) 273-4992
FAX: (909) 273-4123
matzkecj@corona.navy.mil

District of Columbia

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14th Street & Constitution Avenue, NW
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Rockford, IL 61114
(815) 654-5515
FAX: (815) 654-4459
adme3tc@rvc.cc.il.us

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2273 Howe Hall, Suite 2617
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(515) 294-4461
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Appendix F

Navy Manufacturing Technology Centers of Excellence

The Navy Manufacturing Technology Program has established Centers of Excellence (COEs) to provide focal points for the development and technology transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and the Navy industrial facilities and laboratories. These consortium-structured COEs serve as corporate residences of expertise in particular technological areas. The following list provides a description and point of contact for each COE.

Best Manufacturing Practices Center of Excellence

The Best Manufacturing Practices Center of Excellence (BMPCOE) provides a national resource to identify and share best manufacturing and business practices being used throughout government, industry, and academia. The BMPCOE was established by the Office of Naval Research's BMP Program, the Department of Commerce, and the University of Maryland at College Park. By improving the use of existing technology, promoting the introduction of improved technologies, and providing non-competitive means to address common problems, the BMPCOE has become a significant factor to counter foreign competition.

Point of Contact:
Anne Marie T. SuPrise, Ph.D.
Best Manufacturing Practices Center of Excellence
4321 Hartwick Road
Suite 400
College Park, MD 20740
Phone: (301) 403-8100
FAX: (301) 403-8180
E-mail: annemari@bmpcoe.org

Institute for Manufacturing and Sustainment Technologies

The Institute for Manufacturing and Sustainment Technologies (iMAST) is located at the Pennsylvania State University's Applied Research Laboratory. iMAST's primary objective is to address challenges relative to Navy and Marine Corps weapon system platforms in the areas of mechanical drive transmission technologies, materials processing technologies, laser processing technologies, advanced composites technologies, and repair technologies.

Point of Contact:
Mr. Robert Cook
Institute for Manufacturing and Sustainment Technologies
APL Penn State
P.O. Box 30
State College, PA 16804-0030
Phone: (814) 863-3880
FAX: (814) 863-1183
E-mail: rbc5@psu.edu

SCRA Composites Manufacturing Technology Center

The Composites Manufacturing Technology Center (CMTC) is a Center of Excellence for the Navy's Composites Manufacturing Technology Program. The South Carolina Research Authority (SCRA) operates the CMTC and The Composites Consortium (TCC) serves as the technology resource. The TCC has strong, in-depth knowledge and experience in composites manufacturing technology. The SCRA/CMTC provides a national resource for the development and dissemination of composites manufacturing technology to defense contractors and subcontractors.

Point of Contact:
Mr. Henry Watson
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100 Fluor Daniel Engineering Building
Clemson, SC 29634-5726
Phone: (864) 710-2736
FAX: (864) 656-4435
E-mail: watson@scra.org

Electronics Manufacturing Productivity Facility

The Electronics Manufacturing Productivity Facility (EMPF) identifies, develops, and transfers innovative electronics manufacturing processes to domestic firms in support of the manufacture of affordable military systems. The EMPF operates as a consortium comprised of government, industry, and academic participants led by the American Competitiveness Institute under a Cooperative Agreement with the Navy.

Point of Contact:
Mr. Alan Criswell
Electronics Manufacturing Productivity Facility
One International Plaza, Suite 600
Philadelphia, PA 19113
Phone: (610) 362-1200
FAX: (610) 362-1294
E-mail: criswell@aci-corp.org

Electro-Optics Center

The Electro-Optics Center (EOC) is a national consortium of electro-optics industrial companies, universities, and government research centers that share their electro-optics expertise and capabilities through project teams focused on Navy requirements. Through its capability for national electronic communication and rapid reaction and response, the EOC can address issues of immediate concern to the Navy Systems Commands. The EOC is managed by the Pennsylvania State University's Applied Research Laboratory.

Point of Contact:
Dr. Karl Harris
Electro-Optics Center
West Hills Industrial Park
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Phone: (724) 545-9700
FAX: (724) 545-9797
E-mail: kharris@psu.edu

Navy Joining Center

The Navy Joining Center (NJC) provides a national resource for the development of materials joining expertise and the deployment of emerging manufacturing technologies to Navy contractors, subcontractors, and other activities. The NJC works with the Navy to determine and evaluate joining technology requirements and conduct technology development and deployment projects to address these issues. The NJC is operated by the Edison Welding Institute.

Point of Contact:
Mr. David P. Edmonds
Navy Joining Center
1250 Arthur E. Adams Drive
Columbus, OH 43221-3585
Phone: (614) 688-5096
FAX: (614) 688-5001
E-mail: dave_edmonds@ewi.org

National Center for Excellence in Metalworking Technology

The National Center for Excellence in Metalworking Technology (NCEMT) provides a national center for the development, dissemination, and implementation of advanced technologies for metalworking products and processes. Operated by the Concurrent Technologies Corporation, the NCEMT helps the Navy and defense contractors improve manufacturing productivity and part reliability through development, deployment, training, and education for advanced metalworking technologies.

Point of Contact:
Mr. Richard Henry
National Center for Excellence in Metalworking Technology
c/o Concurrent Technologies Corporation
100 CTC Drive
Johnstown, PA 15904-3374
Phone: (814) 269-2532
FAX: (814) 269-2501
E-mail: henry@ctc.com

Energetics Manufacturing Technology Center

The Energetics Manufacturing Technology Center (EMTC) addresses unique manufacturing processes and problems of the energetics industrial base to ensure the availability of affordable, quality, and safe energetics. The EMTC's focus is on technologies to reduce manufacturing costs, improve product quality and reliability, and develop environmentally benign manufacturing processes. The EMTC is located at the Indian Head Division of the Naval Surface Warfare Center.

Point of Contact:
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Energetics Manufacturing Technology Center
Indian Head Division
Naval Surface Warfare Center
100 Strauss Avenue
Building D326, Room 227
Indian Head, MD 20640-5035
Phone: (301) 744-4417
DSN: 354-4417
FAX: (301) 744-4187
E-mail: broughja@ih.navy.mil

Gulf Coast Region Maritime Technology Center

The Gulf Coast Region Maritime Technology Center (GCRMTC) fosters competition in shipbuilding technology through cooperation with the U.S. Navy, representatives of the maritime industries, and various academic and private research centers throughout the country. Located at the University of New Orleans, the GCRMTC focuses on improving design and production technologies for shipbuilding, reducing material costs, reducing total ownership costs, providing education and training, and improving environmental engineering and management.

Point of Contact:
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Gulf Coast Region Maritime Technology Center
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College of Engineering
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New Orleans, LA 70148
Phone: (504) 280-3871
FAX: (504) 280-3898
E-mail: jcrisp@uno.edu

Appendix G

Completed Surveys

As of this publication, 125 surveys have been conducted and published by BMP at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMP web site. Requests for copies of recent survey reports or inquiries regarding BMP may be directed to:

Best Manufacturing Practices Program
4321 Hartwick Rd., Suite 400
College Park, MD 20740
Attn: Anne Marie T. SuPrise, Ph.D., Director
Telephone: 1-800-789-4267
FAX: (301) 403-8180
annemari@bmpcoe.org

1985	Litton Guidance & Control Systems Division - Woodland Hills, CA
1986	Honeywell, Incorporated Undersea Systems Division - Hopkins, MN (now Alliant TechSystems, Inc.) Texas Instruments Defense Systems & Electronics Group - Lewisville, TX General Dynamics Pomona Division - Pomona, CA Harris Corporation Government Support Systems Division - Syosset, NY IBM Corporation Federal Systems Division - Owego, NY Control Data Corporation Government Systems Division - Minneapolis, MN
1987	Hughes Aircraft Company Radar Systems Group - Los Angeles, CA ITT Avionics Division - Clifton, NJ Rockwell International Corporation Collins Defense Communications - Cedar Rapids, IA UNISYS Computer Systems Division - St. Paul, MN
1988	Motorola Government Electronics Group - Scottsdale, AZ General Dynamics Fort Worth Division - Fort Worth, TX Texas Instruments Defense Systems & Electronics Group - Dallas, TX Hughes Aircraft Company Missile Systems Group - Tucson, AZ Bell Helicopter Textron, Inc. - Fort Worth, TX Litton Data Systems Division - Van Nuys, CA GTE C^3 Systems Sector - Needham Heights, MA
1989	McDonnell-Douglas Corporation McDonnell Aircraft Company - St. Louis, MO Northrop Corporation Aircraft Division - Hawthorne, CA Litton Applied Technology Division - San Jose, CA Litton Amecom Division - College Park, MD Standard Industries - LaMirada, CA Engineered Circuit Research, Incorporated - Milpitas, CA Teledyne Industries Incorporated Electronics Division - Newbury Park, CA Lockheed Aeronautical Systems Company - Marietta, GA Lockheed Missile Systems Division - Sunnyvale, CA (now Lockheed Martin Missiles and Space) Westinghouse Electronic Systems Group - Baltimore, MD (now Northrop Grumman Corporation) General Electric Naval & Drive Turbine Systems - Fitchburg, MA Rockwell Autonetics Electronics Systems - Anaheim, CA (now Boeing North American A&MSD) TRICOR Systems, Incorporated - Elgin, IL
1990	Hughes Aircraft Company Ground Systems Group - Fullerton, CA TRW Military Electronics and Avionics Division - San Diego, CA MechTronics of Arizona, Inc. - Phoenix, AZ Boeing Aerospace & Electronics - Corinth, TX Technology Matrix Consortium - Traverse City, MI Textron Lycoming - Stratford, CT

1991	*Resurvey of Litton Guidance & Control Systems Division* - Woodland Hills, CA
	Norden Systems, Inc. - Norwalk, CT (now Northrop Grumman Norden Systems)
	Naval Avionics Center - Indianapolis, IN
	United Electric Controls - Watertown, MA
	Kurt Manufacturing Co. - Minneapolis, MN
	MagneTek Defense Systems - Anaheim, CA (now Power Paragon, Inc.)
	Raytheon Missile Systems Division - Andover, MA
	AT&T Federal Systems Advanced Technologies and AT&T Bell Laboratories - Greensboro, NC and Whippany, NJ
	Resurvey of Texas Instruments Defense Systems & Electronics Group - Lewisville, TX
1992	Tandem Computers - Cupertino, CA
	Charleston Naval Shipyard - Charleston, SC
	Conax Florida Corporation - St. Petersburg, FL
	Texas Instruments Semiconductor Group Military Products - Midland, TX
	Hewlett-Packard Palo Alto Fabrication Center - Palo Alto, CA
	Watervliet U.S. Army Arsenal - Watervliet, NY
	Digital Equipment Company Enclosures Business - Westfield, MA and Maynard, MA
	Computing Devices International - Minneapolis, MN (now General Dynamics Information Systems)
	(Resurvey of Control Data Corporation Government Systems Division)
	Naval Aviation Depot Naval Air Station - Pensacola, FL
1993	NASA Marshall Space Flight Center - Huntsville, AL
	Naval Aviation Depot Naval Air Station - Jacksonville, FL
	Department of Energy Oak Ridge Facilities (Operated by Martin Marietta Energy Systems, Inc.) - Oak Ridge, TN
	McDonnell Douglas Aerospace - Huntington Beach, CA (now Boeing Space Systems)
	Crane Division Naval Surface Warfare Center - Crane, IN and Louisville, KY
	Philadelphia Naval Shipyard - Philadelphia, PA
	R. J. Reynolds Tobacco Company - Winston-Salem, NC
	Crystal Gateway Marriott Hotel - Arlington, VA
	Hamilton Standard Electronic Manufacturing Facility - Farmington, CT
	Alpha Industries, Inc. - Methuen, MA
1994	Harris Semiconductor - Palm Bay, FL (now Intersil Corporation)
	United Defense, L.P. Ground Systems Division - San Jose, CA
	Naval Undersea Warfare Center Division Keyport - Keyport, WA
	Mason & Hanger - Silas Mason Co., Inc. - Middletown, IA
	Kaiser Electronics - San Jose, CA
	U.S. Army Combat Systems Test Activity - Aberdeen, MD (now Aberdeen Test Center)
	Stafford County Public Schools - Stafford County, VA
1995	Sandia National Laboratories - Albuquerque, NM
	Rockwell Collins Avionics & Communications Division - Cedar Rapids, IA (now Rockwell Collins, Inc.)
	(Resurvey of Rockwell International Corporation Collins Defense Communications)
	Lockheed Martin Electronics & Missiles - Orlando, FL
	McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO (now Boeing Aircraft and Missiles)
	(Resurvey of McDonnell-Douglas Corporation McDonnell Aircraft Company)
	Dayton Parts, Inc. - Harrisburg, PA
	Wainwright Industries - St. Peters, MO
	Lockheed Martin Tactical Aircraft Systems - Fort Worth, TX
	(Resurvey of General Dynamics Fort Worth Division)
	Lockheed Martin Government Electronic Systems - Moorestown, NJ
	Sacramento Manufacturing and Services Division - Sacramento, CA
	JLG Industries, Inc. - McConnellsburg, PA
1996	City of Chattanooga - Chattanooga, TN
	Mason & Hanger Corporation - Pantex Plant - Amarillo, TX
	Nascote Industries, Inc. - Nashville, IL
	Weirton Steel Corporation - Weirton, WV
	NASA Kennedy Space Center - Cape Canaveral, FL
	Resurvey of Department of Energy, Oak Ridge Operations - Oak Ridge, TN

1997	Headquarters, U.S. Army Industrial Operations Command - Rock Island, IL
	SAE International and Performance Review Institute - Warrendale, PA
	Polaroid Corporation - Waltham, MA
	Cincinnati Milacron, Inc. - Cincinnati, OH
	Lawrence Livermore National Laboratory - Livermore, CA
	Sharretts Plating Company, Inc. - Emigsville, PA
	Thermacore, Inc. - Lancaster, PA
	Rock Island Arsenal - Rock Island, IL
	Northrop Grumman Corporation - El Segundo, CA
	(Resurvey of Northrop Corporation Aircraft Division)
	Letterkenny Army Depot - Chambersburg, PA
	Elizabethtown College - Elizabethtown, PA
	Tooele Army Depot - Tooele, UT
1998	United Electric Controls - Watertown, MA
	Strite Industries Limited - Cambridge, Ontario, Canada
	Northrop Grumman Corporation - El Segundo, CA
	Corpus Christi Army Depot - Corpus Christi, TX
	Anniston Army Depot - Anniston, AL
	Naval Air Warfare Center, Lakehurst - Lakehurst, NJ
	Sierra Army Depot - Herlong, CA
	ITT Industries Aerospace/Communications Division - Fort Wayne, IN
	Raytheon Missile Systems Company - Tucson, AZ
	Naval Aviation Depot North Island - San Diego, CA
	U.S.S. Carl Vinson (CVN-70) - Commander Naval Air Force, U.S. Pacific Fleet
	Tobyhanna Army Depot - Tobyhanna, PA
1999	Wilton Armetale - Mount Joy, PA
	Applied Research Laboratory, Pennsylvania State University - State College, PA
	Electric Boat Corporation, Quonset Point Facility - North Kingstown, RI
	Resurvey of NASA Marshall Space Flight Center - Huntsville, AL
	Orenda Turbines, Division of Magellan Aerospace Corporation - Mississauga, Ontario, Canada
2000	Northrup Grumman, Defensive Systems Division - Rolling Meadows, IL
	Crane Army Ammunition Activity - Crane, IN
	Naval Sea Logistics Center, Detachment Portsmouth - Portsmouth, NH
	Stryker Howmedica Osteonics - Allendale, NJ
2001	The Tri-Cities Tennessee/Virginia Region - Johnson City, TN
	General Dynamics Armament Systems - Burlington, VT
	Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems - Moorestown, NJ

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A . Report Title: Best Manufacturing Practices: Report of Survey Conducted at Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems, Moorestown, NJ

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F. The foregoing information was compiled and provided by:
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